NEURODIVERSITY-AFFIRMING SOCIAL SKILLS INTERVENTIONS BY SOCIAL ROBOTS FOR AUTISTIC INDIVIDUALS: A SCOPING REVIEW

A Thesis submitted to the faculty at Stanbridge University in partial fulfillment of the requirements for the degree of Master of Science in Occupational Therapy

by

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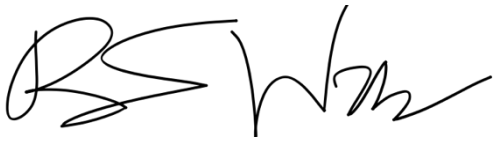
Certification of Approval

I certify that I have read *Neurodiversity-Affirming Social Skills Interventions by Social Robots for Autistic Individuals: A Scoping Review by* Thy Anh Hoang, Claudia Casillas, Matthew Lopez, and Leslie Villegas-Patterson, and in my opinion this work meets the criteria for approving a thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Occupational Therapy at Stanbridge University.



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Dedication

To my beloved parents Lydia and Federico,

Throughout my educational journey, you have been my strong pillars of support, guiding me with love, encouragement, and boundless belief in my abilities. Your sacrifices, countless phone conversations, and unwavering faith in me have been the driving force behind my academic success. This thesis is a testament to the profound impact of your love and dedication on my life. Thank you for all of your support, I love you both!

To my cherished husband,

From the moment we embarked on this graduate school journey together, you have been my rock and my constant source of inspiration. Your constant support, patience, and understanding have empowered me to pursue my dreams with determination. This thesis is as much a reflection of your commitment to our shared goals as it is of my own.

With all my love,

Leslie Dalyf Villegas-Patterson

This thesis work is dedicated to my wonderful husband, Gabriel Casillas, who has been a constant source of support and encouragement during graduate school and life. I am genuinely thankful for having you in my life. This work is also dedicated to my dearest parents, Nilton and Nancy Leon, who have loved me unconditionally. Their exemplary dedication to integrity, hard work, and moral values have taught me to navigate life's challenges with resilience and to pursue and achieve my goals.

With love,

Claudia Elizabeth Casillas

This work is dedicated to my parents, Chau Phan and Huy Hoang, for their unconditional support and patience. I will always be grateful for the sacrifices you have made to allow me to get to this point. I would also like to dedicate this work to my cat, Ren, for being my greatest moral support during my graduate career.

Love,

Thy Anh Hoang

I would like to dedicate this work to my loving family who have supported me through thick and thin. I am truly grateful to have a loving family who have supported me in all my endeavors in my academic career. To my brother, Jason, my mother June, and my father Victor who have guided me and showed me unconditional love in my life. I am truly grateful to have you all in my life.

Love,

Matthew Ryan Amorin Lopez

Abstract

Introduction: Research indicates that social robotics effectively assists individuals with autism spectrum disorder. However, these practices may not align with the principles of neurodiversity-affirming approaches, which emphasize acceptance and recognition of neurological differences. Most existing frameworks are rooted in Applied Behavior Analysis (ABA) methodologies, which a significant portion of the autistic community opposes due to ABA's tendency to normalize and enforce conformity to societal norms. This research will educate attendees about the importance of neurodiversity-affirming practices in occupational therapy (OT) and how social skills interventions provided by social robotics impacts the autistic community.

Methods: The research is a scoping review of literature regarding social skills interventions implemented by social robotics for autistic individuals and their neurodiversity-affirming implications. Search terms for this research were as follows: “autism,” “ASD,” “autism spectrum disorder,” “robotics,” “social robotics,” “social skills,” “neurodiversity-affirming,” “ABA,” “applied behavior analysis,” and “strength-based.” Search terms were run through the databases ProQuest Nursing and Allied Health Source, PsycINFO, Pubmed, CINAHL Complete, Medline Complete, Academic Search Complete, and ERIC.

Results: From an initial pool of 20 research articles, 12 were selected for a comprehensive review. The findings revealed that social robotics interventions hold promise in enhancing social skills, communication, and emotional regulation for autistic individuals across various age groups. While many interventions were rooted in traditional ABA approaches, some exhibited alignment with neurodiversity-affirming

approaches, introducing elements like personalized instruction and recognition of an individual's preferences. Limitations were identified, including the scarcity of comprehensive articles due to the emerging nature of neurodiversity-affirming approaches and robot-mediated autistic interventions. Notably, the absence of human subjects in the study eliminated concerns related to recruitment, dropouts, and scheduling. **Conclusion:** This scoping review addressed the importance of neurodiversity-affirming approaches in social skills interventions using social robotics for autistic individuals with a call for further research to refine these approaches, align them with neurodiversity principles, and address associated challenges. This research contributed to informing the OT community regarding neurodiversity-affirming practices. It explored the potential benefits and challenges associated with these interventions and their alignment with the principles of neurodiversity, ultimately contributing to a more comprehensive understanding of effective and inclusive social skills interventions for autistic individuals.

Keywords: autism, ASD, autism spectrum disorder, robotics, social robotics, social skills, neurodiversity-affirming, ABA, applied behavior analysis, strength-based.

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Neurodiversity-Affirming Social Skills Interventions by Social Robots for Autistic Individuals: A Scoping Review

In order to develop a more comprehensive understanding of effective and inclusive social interventions for autistic individuals, it is essential that we implement neurodiversity-affirming approaches that acknowledge the unique strengths, interests, and needs of all neurotypes. Neurodiversity refers to the idea that there are various expressions of human cognition and communication patterns, and that neurodivergent individuals display common deviations from typical representations of neuronal and behavioral traits (Goldberg, 2023). The discussion of neurodiversity-affirming approaches seeks to raise awareness and appreciation for the diversity in human cognition. Centering autistic people's experiences allows others to understand that autistic people live rich, full, and interesting lives, not in spite of an autism spectrum disorder diagnosis, but because of their embodied autistic experience (Dallman et al., 2022). The American Occupational Therapy Association research agenda continues to discuss a theoretical shift within occupational therapy (OT) that views autism not as a behavioral disorder but as a form of neurodiversity (Williams et al., 2021). OT focuses on an individual's meaningful activities, so supporting neurodiversity confirms the priorities of the autistic community. With the increasing use of technology in healthcare, robotics have become a modality used in autism intervention (Alghamdi et al., 2023); however, critical analysis is needed to determine their compatibility with neurodiversity-affirming approaches. Interventions implemented by social robots offer a non-judgmental approach and consistent presence, but the framework of the interventions may not adhere to neurodiversity-affirming principles.

Applied behavior analysis (ABA), the most prominent intervention framework for autism, is the primary framework utilized in interventions provided by social robotics (Wilkenfeld & McCarthy, 2020). However, it is under ethical scrutiny by advocates of the neurodiversity movement. ABA is completed by systematically redirecting an autistic individual away from their dispositions, attachments, and desires towards behaviors that oppose these attitudes (Wilkenfeld & McCarthy, 2020). The autistic community has spoken out in opposition to behavioral practices in ABA because they are centered around conformation to normative societal practices and value compliance over other concerns (Dallman et al., 2022). Non-neurodiversity-affirming approaches typically negate neurodivergent bodily autonomy and do not support neurodivergent play styles. ABA often uses non-neurodiversity-affirming conditioning techniques that punish autistic individuals for presenting “challenging” or aggressive behaviors. Unlike ABA and other non-neurodiversity-affirming approaches, the neurodiversity-affirming approach aims to support individuals with co-regulation, identify their environmental triggers, and acknowledge that their aggressive and “challenging” behaviors are a response to their autonomic nervous system. There has been research suggesting that autistic children treated through ABA report significantly more PTSD symptoms than children who were not treated with ABA (Kupferstein, 2018). The focus of repeated actions to achieve compliance leads to an individual’s perceived lack of control, diminishing self-esteem, motivation, and autonomy (Sandoval-Norton & Shkedy, 2019). This intensive conditioning contributes to adult reliance and learned helplessness, often triggering sensory overload and autistic shutdowns (Dallman et al., 2022).

The endpoint of our study is to contribute to better informing the OT professional community regarding the use of this approach, particularly considering the growing momentum towards adopting neurodiversity-affirming practices in interventions used with autism. Our study aims to provide OT practitioners with well-informed analyses regarding the appropriateness of utilizing social robotics as a modality for intervention, which can potentially be accomplished by adapting social robotic interventions around the unique needs and preferences of autistic children and avoiding the behavioral conditioning techniques used in ABA. While there is no current common consensus for the specific criteria of neurodiversity-affirming interventions, we mapped an additional analysis of neurodiversity-affirming practices onto the existing critiques of ABA and social robotics in order to guide future research. The intended audience for this scoping review consists of OT practitioners who work directly with individuals diagnosed with autism spectrum disorder (ASD). This review is intended to provide valuable information to OT practitioners about the benefits and challenges of incorporating neurodiversity-affirming approaches into social robotics as an intervention modality. We anticipate that our findings will provide insights to guide future research into how OT practitioners can approach neurodivergent populations and implement neurodiversity-affirming practices into their interventions. Implications of our work will contribute to better informing the OT profession's community regarding the use of this approach, particularly considering the growing momentum towards adopting neurodiversity-affirming practices in interventions used with autism. The aim of this paper is to encourage unique understandings of personal wellness, respect variations in social participation, and facilitate the development of social abilities for autistic individuals.

Statement of Purpose, Hypothesis and Research Question

The lack of empirical research and understanding regarding the neurodiversity-affirming nature of social skills provided by social robots for autistic individuals of all ages raises inquiry about the effectiveness and inclusivity of such interventions. Despite our hypothesis that the use of social skills curriculum offered by social robots can lead to improved social skills outcomes, it remains uncertain whether these interventions are actually neurodiversity-affirming. The problem addressed in our study is whether the use of social skills curriculum provided by social robots is genuinely neurodiversity-affirming for autistic people of all ages. Our research aims to fill the gap in knowledge by exploring the potential benefits and challenges associated with these interventions and their alignment with the principles of neurodiversity, ultimately contributing to a more comprehensive understanding of effective and inclusive social skills interventions for autistic individuals.

Despite the evidence that the use of social skill curriculum offered by social robots can lead to improved social skills outcomes, our hypothesis is that those interventions are not neurodiversity-affirming. After reviewing background literature, our research question was determined as follows: “Is the use of social skills curriculum provided by social robots neurodiversity-affirming for autistic people of all ages?”

Literature Review

In conducting our literature review, we analyzed peer-reviewed research articles to investigate if social robotics provides neurodiversity-affirming practices in a larger effort to emphasize the importance of inclusivity and acceptance towards the autistic community. In OT, social robots play a crucial role in assisting the development of

autistic individuals. These robots offer a non-judgmental, reliable, and consistent social presence, which can assist autistic individuals in enhancing their social abilities and enhancing their overall well-being. According to van den Berk-Smeekens et al. (2021), robots have the potential to attract autistic children, thereby fostering their motivation for social interaction. Initial research also indicates that robotic systems can effectively engage and direct the attention of young autistic children (Zheng et al., 2020). By observing interactions between autistic individuals and social robots, researchers can gain insights into social behavior and communication difficulties with ASD. Rakhymbayeva et al. (2021) suggest that autistic children not only respond well to robots, but also are engaged and focused on the interventions provided when the interventions revolve around the things that they like and are interested in. According to Raptopoulou et al. (2021), “a growing number of studies have been investigating the application of advanced interactive technologies to address core deficiencies related to autism, such as in social communication.” These findings can be used to future researcher's advantage by supporting the idea of developing neurodiversity-affirming social robots, so that they conform to the child and not the other way around.

Schweinberger et al. (2020) found in a correlational study that older adults with reported higher autistic traits rated humanoid robots as more likable than young adults with autistic traits. This study was conducted by showing participants experimental videos then providing a questionnaire, so there is a weakness in how videos do not accurately represent real human-robot interaction behavior. However, the indication that the adult population also finds robots engaging is beneficial to understanding how robots

can affect different populations. Evaluating the effects of robots on autistic adults may motivate exploration of the potential of social robotics.

Social robots already have the ability to provide personalized instruction and feedback for the individual needs of the person; these systems register the individual's gaze and provide reinforcement by offering verbal praise, allowing for simultaneous social communication (Zheng et al., 2020). Some robots can also recognize gestures and cues, and they adapt their responses depending on the relationship with the user (Thalmann, 2022). Rakhymbayeva et al. (2021) suggested further research should be conducted into social robot assisted therapy that targets joint attention, imitation, turn-taking skills, and emotional well-being of the participants. The utilization of social robotics in interventions also proves advantageous due to the adverse impact of sensory overload caused by human interviewers on the social signal processing of autistic (Kumazaki et al., 2022). Social robots are applicable in therapeutic contexts to establish a secure and regulated environment where autistic individuals can engage in social skill practice and communication. By offering feedback and guidance, social robots aid in the development of crucial communication skills for autistic individuals. Social robotics technology, aside from providing a social skills curriculum, can also be used in healthcare settings to provide care and support for individuals with disabilities, in elderly care settings to provide companionship and support, and as a supplemental tool in OT (Ragno et al., 2023).

When using social robotics in OT, a profession that is client-centered, it is morally imperative that the social robots be neurodiversity-affirming. Many social robots use approaches inspired by traditional ABA in their interventions, such as the one that is mentioned in the article written by Rakhymbayeva et al. (2021). OT practice frequently

incorporates techniques from ABA in interventions. These approaches, including reward systems, the use of charts to prioritize preferred and less preferred activities, promoting compliance through physical guidance or restricting movement, planned ignoring, and other behavioral methods, rely on the therapist to shape the desired behavior while disregarding the child's internal experience of the intervention (Dallman et al., 2022). The ABA approach, though effective, is not neurodiversity-affirming. A study from Salimi et al. (2021) concurs, as the results suggest that robots are most beneficial in interventions involving shaping and imitation to correct eye contact and assume emotions based on socially appropriate behaviors, which rejects the neurodiversity-affirming approach. Similarly, a systematic review by Sartorato et al. (2017) discusses the range of therapeutic effects on autistic children, where a majority of social robotics focus on reducing interfering behaviors, increasing social interactions, and increasing "appropriate" social behaviors. Overall, the use of social robotics with autism has the potential to improve the lives of autistic individuals and contribute to our understanding of their social behavior and communication, but there is still work to be done in equipping these robots with interventions that are neurodiversity-affirming.

Common Themes

The search for more evidence in neurodiversity confirming social robotics is prevalent in research, but there have been few studies that address the impact on social robotics for autistic individuals. Among the existing literature on this topic, there is a common theme of exploring the actual impact on social strengths and vulnerabilities of these individuals. For example, Zheng et al. (2020) conducted a study on joint attention intervention systems addresses the need for more early age intervention. Despite previous studies about the growing interest for social robotic intervention, there have been very

few controlled trials in relation to testing these types of robotic sessions (Zheng et al., 2020).

Additional studies also seek to advance the impact on social capabilities for autistic individuals. Pivotal response treatment (PRT), a treatment that supports early age intervention, was conducted to see how it might impact social behaviors (van den Berk-Smeekens et al., 2021). It was found that in the follow-up sessions after PRT and robotic PRT interventions, autistic children showed the largest increase in motivation and social capabilities compared to those who had human PRT sessions. Robotic assistance was found to enhance learning environments that helped to promote higher motivation and attention (van den Berk-Smeekens et al., 2021). Overall, both of these studies contribute to finding robotic interventions that impact social vulnerabilities and capabilities of autistic individuals, but there is still a need to explore the impact in various areas of social themes in addition to neurodiversity-affirming studies.

Several studies also address a common theme of advancement in robotic technology to help assist autistic individuals with social and adaptive interactions. This stems from the common interest found in autistic individuals for robotic technology. Kumazaki et al. (2021) address the need for continual advancement in the virtual world to aid in social and adaptive skills as a means to help assist individuals in job interviews. In a functional near-infrared spectroscopy study, it was also found that most autistic children have different functioning patterns in the dorsolateral prefrontal cortex (Hou et al., 2022). They found that autistic children generally find it more difficult to engage in human interaction as opposed to robotic interaction, leading to a discussion that more robotic intervention may be needed to improve upon human interactions (Hou et al., 2022). These results were found by looking at the neural pathways between autistic and

neurotypical children in relation to human and robotic interaction. Both studies address the underlying theme for a need in the advancement of robotic technology to assist social and adaptive interactions in autistic individuals.

Huijnen et al. (2017) identified that to effectively implement robots for autistic children, we need to consider more than just the robot's appearance, voice, operation, and attributes. Personalizing the robot to the individual (i.e. the robot's appearance and behavior) is crucial. However, additional factors such as the professional's role, environment, and educational integration are also key to successful implementation. Additionally Huijnen et al. (2018) identified a common theme concerining the need for individualized approaches that can adapt to changing needs, such as choosing different roles for the child based on their needs. Customizable robotic experiences can be tailored to many children who need further assistance in social interaction (Yun et al., 2017). Puglisi et al. (2022) discovered that physical appearance and mobility are the most significant factors in improving human-robot interaction for ASD interventions. This aligns with other studies, such as Cano et al. (2021), who suggest a more comprehensive approach to developing a robot system that addresses the needs of all stakeholders, addressing a common underlying theme that emphasizes the importance of personalizing the robot to the individual's needs within the context of ASD interventions. The procedure of Pennazio's (2017) study was broken up into different phases to make it possible to collect data during different activities across time, and gradually modify the robot's behavior after new activities. The researchers did not address sampling until redundancy in data was reached. However, the researcher did discuss results already reported in literature and sampling with autistic individuals with robot-mediated interventions.

Identification of Gaps in Knowledge

Although there have been significant advances in the field of autism and robotics in recent years, we still lack knowledge in highlighted areas. Both van den Berk-Smeekens et al. (2021) and Zheng et al. (2020) found little well-designed randomized control trials on PRTs and supervised studies of the therapeutic effects of robots used to treat ASD, respectively. In a study by Yun et al. (2017) analyzing results of robot-mediated behavioral treatments for autistic children, it is possible that stratifying the subjects according to various levels due to the small sample size may have interfered with the statistical analyses. These preliminary results not only need to be confirmed in bigger sample sizes but also with typically developing children in a different control group. Additionally, all of the participants were male, so the findings cannot be generalized to female autistic participants. Due to difficulties in follow-up trials and controlling confounding variables, determining the long-term maintenance impact focusing on cognitive behavioral treatment of ASD is difficult. As a result, there is not enough research in this field. Lastly, depression/anxiety subscale scores decreased, leaving the assumption that the therapy may have an impact on comorbid issues. According to Yun et al. (2017), further research is needed to show a cause-and-effect relationship between these variables. Moreover, future research might to consider the evolution of more varied facial expressions, activities involving social referencing, conversation, turn-taking, joint attention, social skills training scenarios, and incentive schemes that are tailored to the needs, interests, and social skills of each subject.

Kumazaki et al. (2022) also concluded that bigger samples, inclusion of female participants, and diverse ethnicities, are required to provide more insightful information about the potential application of the system and make the results more generalizable.

According to Kumazaki et al. **t**he research was also unable to determine whether the program is applicable to real-world interviews. Long-term longitudinal studies incorporating job support facilities are also required in the future. Lastly, due to COVID-19 measures during the study, the research group was unable to have a control group, hence the need for control groups in future studies (Kumazaki et al., 2022). There are still several areas on autism and robotics that have not been thoroughly explored, leaving important gaps in our knowledge.

Overall, there is still a gap in knowledge due to limited progress in clinical applicability of robot-mediated interventions due to the lack of standards of success in robot-based studies (Huijnen et al., 2018). Huijnen et al. (2018) also identified an absence of age, ethnicity, and socioeconomic position variables that could have amplified identifiable patterns and differences in experiences. Pennazio's (2017) review of efficient characteristics of social robotics within education and rehabilitative settings also indicates he need for studies involving robots navigating therapeutic environments. This emphasizes the discussion of changing inclusion criteria and approaching diversity for appropriate clinical application. Generalization in clinical application is also limited, as there is a lack of research on the generalizability of social robotic therapies to human social interactions (Sartorato et al., 2017).

Gaps in social robotics for autistic individuals also include obstacles with the robots themselves. There may be limited expression and mobility functions in certain robots, which may impede an intervention’s potential to make a therapeutic session more engaging (Puglisi et al., 2022). Despite the call for robots to be personalized to the client and have an adaptive appearance, few studies have found if robots can truly be integrated for intelligent and emotional communication (Cano et al., 2021). Understanding the

ability for a robot to create dynamic interactions is useful for developing robot-mediated interventions. Huijnen et al. (2017) address the gap in knowledge of the success of dynamic interplay due to differences in robotic platforms. This indicates a need for customizable robot-assisted interventions for tailored personalization (Huijnen et al., 2017).

Clinical Significance

Based on preliminary background information, there is significant evidence for behavioral change in autistic individuals from robotics interactions and moderate evidence for increased performance during social interventions. Various qualitative articles addressing the role of humanoid robots in autism interventions advocate for the positive indications of robot-mediated interventions.

Kumazaki et al. (2022) discuss an effect of virtual robotics used in job interview training with autistic individuals, suggesting that robotics training sustains motivation and enables greater self-confidence. Conversely, Zheng et al. (2020) found no significant pattern of response in autistic individuals with robot-mediated responses to joint attention interventions. The difference in significance of findings has implications of differentiations between types of robot-mediated interventions. Studies are mixed on the effectiveness of robot-mediated responses during ASD interventions due to the lack of controlled trials. Overall, the literature supports robot-assistance in intervention efficacy for autistic individuals, but it does not support specific aspects of social learning such as attention interventions. Understanding the roles, strengths, and challenges of using robots in interventions for autistic children can be helpful for care and education professionals such as occupational therapists in deciding whether to use social robots or not and how to

use them effectively (Huijen et al., 2018). It can also inform the development of future interventions and the design of robots for this purpose.

The clinical significance exhibited in the article by Huijnen et al. (2017) is the understanding of how to implement robotics in interventions for autistic children by involving a large number of ASD practitioners and other stakeholders in the field in focus groups and co-creation sessions. They found that besides requirements related to the robot itself, personalization to the needs of the individual child is crucial, and factors such as the role of the professional, the environment, and educational and organizational integration will be key in practice. This underscores the importance of robot research being sensitive to end-users' requirements to overcome typical barriers for robot-mediated interventions to reach clinical applicability. The intervention template developed by Huijnen et al. (2017) out of evidence-based practice provides insight on how to actually embed robots in current education and/or therapy practices for autistic children, which could potentially improve patient care and clinical practice in this area. Per Puglisi et al. (2022), there is importance of designing an effective social robot tool for autistic children. They discuss the challenges of robot-designing, including the need for a human-like appearance and good mobility, the ability to detect the child's position and movements, and the ability to express complex emotions. They also stress the importance of a robot having numerous capabilities for researchers, care professionals, and children to increase the efficiency of robot-assisted cognitive therapy approaches for ASD. A robot with a more human-like appearance may also help the child feel more reassured during interventions (Pennazio, 2017). Social robotics could also be used as a tool for social skills derived from imitation, as Pennazio (2017) addressed positive results between a child correctly imitating a robot during interactions with a peer. Ultimately, the

goal was to design and develop a robot with high levels of utility, availability, safety, and acceptability in order to effectively treat autistic children.

Conclusion

After reviewing the common themes of literature and significance on autism and social robotics, we believe that robot-mediated interventions for social communication can be useful for both short-term goals and long-term goals. Zheng et al. (2020) state that there may not be any defining impacts on crucial skill domains, but we say that there is still intervention efficacy in robot-mediated treatments for autistic individuals. In discussions about lasting impacts of social skills and adaptive skills with robot facilitators on autistic individuals, we agree that there is an insubstantial amount of evidence that can support the effects of robot-facilitated treatments. Huijnen et al. (2018) address the limited advancements in clinical applicability, so we need to consider how future studies can progress research. On the other hand, we believe that autistic individuals sustain more attention with robotic facilitators than with human facilitators, which could assist in learning social communication skills that would otherwise be too overstimulating with a human facilitator. This is implied in the study by Hou et al. (2022), which suggests that there is increased attention in brain activity with robots. Although the specific domains of interventions may require more research to reach a conclusion, we believe that there is support for using robots as effective methods in clinical settings. However, in regards to neurodiversity-affirming approaches within social robotics, robot-mediated interventions may not be ideal for autistic individuals. Although they have been studied to assist in social skills interventions, there are still possible limitations in relation to their neurodiversity-affirming aspect.

Theoretical Framework

In this study, we explored the utilization of the neurodiversity-affirming model. The neurodiversity-affirming model is a framework that emphasizes inclusivity and acceptance, recognizing that neurodivergent individuals have different brains and minds, and they deserve to have the same rights and opportunities as neurotypical individuals (Dwyer, 2022). The term "neurodiversity" was first coined by Judy Singer in her 1997 undergraduate thesis (Singer, 2017, p. 17) . The term was further popularized by Harvey Blume in an article in *The Atlantic* (Blume, 1998). Neurodiversity includes various conditions such as attention-deficit/hyperactivity disorder, autism, dyslexia, developmental language disorder, complex tic disorders, dyscalculia, dysgraphia, and dyspraxia, or any other neurological differences; a mix of these differences can influence how someone processes and interacts with their environment and others (Mills, 2022). Instead of seeing these diverse neurological conditions as problems, the neurodiversity framework celebrates them as part of human diversity. While no fixed definition exists, the neurodiversity approach emphasizes embracing and appreciating neurological differences (Dwyer, 2022).

The neurodiversity-affirming model is crucial because it offers an alternative perspective to the traditional medical model of understanding neurological differences, such as autism as the result of atypical development (Dwyer, 2022). According to Dwyer (2022), the medical model views disabilities as disorders that must be cured or normalized. However, the neurodiversity-affirming model values the unique strengths and perspectives of autistic individuals and other neurological characteristics rather than

seeing them as problems to be fixed. This approach challenges the notion that everyone needs to conform to a neurotypical standard and highlights the importance of acknowledging and accepting neurological differences (Dwyer, 2022).

To support the neurodiversity-affirming model within the context of autism and robotics research, it is crucial to examine the approaches and methods used carefully. Since our literature review revealed that ABA remains the primary intervention model for social skills curriculum in robotic therapy, we need to explore alternative models that are more aligned with the principles of neurdiveristy-affirming care. While ABA has been widely used in the field, it has also received criticism from a large majority of the autistic community for its focus on normalization and compliance according to the norms of society (McGill & Robinson, 2020). A study by Kupferstein (2018) found that almost half of the ABA-exposed participants showed PTSD; however, non-exposed controls had a 72 percent chance of being symptom-free. In contrast, the neurodiversity-affirming model values and embraces the diverse range of neurological differences, and emphasizes valuing the unique strengths and perspectives of autistic individuals, instead of seeing autism as a problem to be fixed. Embracing neurodiversity helps create a more inclusive and supportive environment. Social robots providing social skills curriculums can benefit autistic individuals of different ages. However, it is crucial to ensure that these interventions follow the principles of the neurodiversity-affirming model.

To support the neurodiversity-affirming model in our research, we must focus on finding and using robotic interventions that prioritize the well-being, autonomy, and individuality of autistic individuals without relying solely on ABA techniques. This

might involve creating social robots that accommodate different communication styles, sensory sensitivities and cognitive differences. This could even provide a step towards enhancing ABA techniques by valuing the input of autistic individuals and other neurological differences (Graber & Graber, 2023). By doing this, our research can align with the principles of neurodiversity, promoting inclusivity and empowerment in how researchers and clinicians support autistic individuals through robotics. Using neurodiversity-affirming robotic methods has the potential to create individualized and improved interventions for autistic individuals of all ages. This approach focuses on their well-being, self-acceptance and inclusion in society, making the interventions client-centered, meaningful, and effective.

Methodology

The method of study of this research project is a scoping review. The purpose of this review is to assess current literature to identify the nature of research evidence involving autism and social robotics. Advantages of a scoping review include mapping the literature to inform future research. This serves to determine the path of future research of neurodiversity-affirming approaches in social robotics in autism intervention. Our study used the Population/Participants, Concept, and Context framework (PCC) as a guide to construct questions used for the scoping review.

We developed research protocols around sources of evidence from peer-reviewed journal articles and book publications. We extracted data by determining the relevancy of the articles based on the given search terms and subsequently analyzed on the usage of neurodiversity-affirming practices in the intervention process. Our search process of the

PCC framework consisted of conducting foundational research of key concepts, which included quantitative and qualitative method studies using a combination of the search terms: “autism,” “ASD,” “robotics,” and “social robotics.” We filtered literature for publishing years of 2013-2023, written in English, and involving human participation. We limited literature to 10 years in order to ensure relevancy of knowledge as fields change quickly with the acquisition of new data from research. We limited our search to literature wriiten in English as a time-saving factor due to a lack of resources to translate international publications. Our search required our participation to maintain validity for assessment with autistic individuals. We limited the study population to the autism population and defined as individuals diagnosed with ASD. We did not limit the age of the population, and we included quantitative and qualitative method studies. We searched the databases ProQuest Nursing and Allied Health Source, PsycINFO, Pubmed, Google Scholar, CINAHL Complete, Medline Complete, Academic Search Complete, and ERIC. Background information must have included the discussion of social skills, robotics, and autism. We determined our research question, research problem, and methodology through discussions with our thesis advisor and through our preliminary search of background information. We conducted an additional search on neurodiversity-affirming practices to include in background information using search terms: “neurodiversity-affirming,” “neurodiversity-affirming approach,” and “neurodiversity-affirming practice.”

To identify potential relevant documents for literature review, we searched for additional literature. Search terms for each database were as follows: “autism,” “ASD,” “autism spectrum disorder,” “robotics,” “social robotics,” “social skills,” “neurodiversity

affirming," "ABA," "applied behavior analysis," and "strength-based." We manually removed duplicate publications and requested publications with limited access through an interlibrary loan through the Stanbridge University Library. We subsequently evaluated literature titles, abstracts, and full texts to identify relevance of publications to the topic area. We began by importing references to a Microsoft Excel sheet and screened titles and abstracts before moving onto full-text screening. In addition to search limitations of year and language, publications chosen for review must have included studies focusing on autistic individuals at any age, the use of robotics in the methodology, and the description of the robotic intervention discussed. To increase consistency among reviews, we screened the same publications and discussed the results then charted our results to analyze publications' intervention results and discussions. We charted the author, year of publication, aim and purpose of the study, population and sample size if applicable, methodology, intervention type, outcomes, and critical findings related to our research question.

We determined the level of use of neurodiversity-affirming practices in the interventions based on the neurodiversity framework. We used qualitative publications to identify the purpose of specific robotic interventions in order to analyze the neurodiversity-affirming practices of the author's general methods of using robots. Based on the definition of neurodiversity-affirming practices according to some of the autistic population, we identified certain methodologies in social robotics as non-neurodiversity-affirming. We concluded ABA interventions as non-neurodiversity-affirming. We did not focus on assessing the validity of publications for continued use. Our study did not use

any data collection instruments, equipment, teaching aids, or standardized evaluation instruments.

Ethical and Legal Considerations

Implications of ethical and legal considerations were reduced due to the lack of human subjects within this scoping review, meaning our project did not require approval from the Stanbridge Univeristy Institutional Review Board. Nevertheless, there are ethical concerns that warrant discussion in light of research gaps. Our research revealed that social robotics favors principles of ABA. ABA leans heavily on principles that break behaviors and implement tasks that demand repetitive behaviors for autistic individuals (Garber & Garber, 2023). Although research with social robotics is a relatively new topic in discussion for intervention means, there are no mentions of how these interventions might support a neurodiversity-affirming framework. Addressing the reasons why social robotics only implements ABA principles can be further expanded upon in future studies.

The main ethical and legal considerations lie heavily in the tone of how robotic interventions are used for the autistic community. Robotic interventions, in current research, serve to change behaviors of autistic individuals and analyze various emotional behaviors to these changes (van den Berk-Smeekens et al., 2021). Ethical liabilities can be understood through the lens of these changes in behavior. There is no clear evidence to how ABA styled interventions serve to improve social skills and interactions on an incentive-based structure. ABA principles rely on a molding structure presented through the perspective of those solely working with autistic individuals (Garber & Garber, 2023). ABA promises changes in behaviors that are deemed for the benefit of autistic individuals but can cause harm based on the OT core values of dignity, freedom, and

equality. These behaviors are subjected to fit criteria of mainstream society and outside perspectives from non autistic individuals therefore, there is a need for further studies suggesting how robotic interventions are neurodiversity-affirming for all ages. This scoping review has addressed how social robotics can be neurodiversity-affirming in light of intervention tactics that rely on principles which govern a molding framework for autistic individuals.

Results

The study selection process and a summary of the initial screening of articles are presented first, followed by a general overview of the results. Next, the main results from articles chosen from the review are presented according to our review objectives.

Discussion

The completion of search records resulted in an initial screening of 20 articles, 12 of which were deemed relevant for full text review and eligible for inclusion into the scoping review (See Tables 1 and 2). This scoping review summarizes the implication of neurodiversity-affirming approaches on the use of social robots with autistic individuals. The American Occupational Therapy Association discusses a research agenda that promotes a theoretical shift within OT that views autism as a pervasive developmental disorder (Williams et al., 2021). We aimed to examine the purpose, the methodology, the robot-mediated interventions, the outcomes of the interventions, and a critical analysis of the study as well as the neurodiversity-affirming aspects overall. We highlighted the key aspects of each study and found that social interventions implemented by social robots for autistic individuals are generally not neurodiversity-affirming. The analysis of these studies was based on how much they utilized a neurodiversity-affirming approach within

the interventions. As previously mentioned, neurodiversity-affirming approaches are reached when interventions allow them to participate in stereotypical behaviors as opposed to direct social attention which molds them to a specific behavior. Most studies are affirming of robotic interventions for autistic children, but there was a lack of understanding when it came to the overall discussion on how to improve on individual approaches. The goal of this scoping review is to inform readers on how said interventions lack an individualistic approach in providing a more meaningful way of interaction with the autistic community through robotic interventions. We dissected these articles as a means of addressing the current knowledge on how social robots are approached for interventions. What remains elusive is the understanding on how these approaches deem fit for all ages.

A common purpose behind these these studies was to evaluate the behavioral effects of robot-mediated interventions and provide more research on the potential of these interventions. A recurring theme of these studies was centered around the novelty of robots used in autism interventions, so the aims of these articles surround presenting more data on robot-assisted therapy and how to integrate robots in rehabilitation services for autistic individuals. Findings based on the twelve articles suggest a continuous need for research on social robotics with regard to autistic individual's interventions. However, based on our research question, the need for continued analysis on neurodiversity-affirming interventions for all ages may still serve to guide future research. The articles we reviewed highlight advantages to why social robotic interventions clarify social intonations with autistic children. Outcomes from social robotic interventions within the research suggest that these interventions improved independence, improved navigation in

social situations, and overall quality of life in many autistic children. Signs of improved verbal skills and non-verbal skills can also be seen in the articles. Moreover, our scoping review strives to emphasize the importance of designing robotic interventions to fit the individual. Sætra et al. (2022) demonstrated how there is a need to design robots in light of a normative standard. The social interventions should help provide meaningful feedback to the child, and the feedback should be incorporated in specific interventions that suit the child as opposed to a unified experience for all, which limits their individual goals.

The most common robot-mediated interventions were based on ABA. A study by Srinivasan et al. (2016) gives insight into how autonomy is compromised when the interventions are constrained, demarcated, and predictable in order to increase compliance with autistic children. ABA may cause concern for social robotic interventions in relation to direct social attention, as its normative approach. Neurodiversity-affirming practices are used when there is a chance for the autistic child or individual to participate in stereotypical behaviors others may receive in interventions. Overall, because of direct social attention or training, this limits the children from being able to truly express their understanding of social skills due to training them to fit a neurotypical social environment.

Most studies in this review focused on implementing interventions using a humanoid robot or semi-autonomous robot, and a majority of the studies used the humanoid robot NAO. Overall, the researchers suggested that robotic interventions display promise of effective and efficient use of therapy compared to human therapists. Korneder et al. (2021) found that social assistive robots can help to teach new social

skills not previously known to the child. However, this study was conducted under the basis of ABA therapy which again limits the interaction between the individual and the robot to fit societal norms. This hinders the interaction due to the lack of the focus on strengths but rather focuses on fitting the individual to the normative of society. Furthermore, this is an indication as to what needs to be done on robotic interventions to fit an individualistic treatment plan and limit the barrier on social norms to truly meet the requirement of a neurodiversity-affirming approach. Although the robots are recognized in the studies as being engaging and effective for learning support, they do not address the autonomous effect in autistic individuals.

A more holistic approach in regard to OT may include approaching robotic therapy with a lens of individualistic care, advocacy of particular robotic interventions as research continues to develop for these types of interventions. Education on social robotic interventions and family education as means of community advocacy to normalize robotic interventions within the home, school, or clinical arena. Clinical judgment is required from the occupational therapist based on the individual and the setting of the intervention, but implications from this review showcase a deeper understanding of why there is a need for neurodiversity-affirming interventions. Seeking methods to introduce a more holistic view of social robotic interventions may coincide with a better understanding of how to approach them as an occupational therapist.

Implications and Future Recommendations

The outcomes of this review suggest the evaluation of therapeutic benefits and neurodiversity-affirming interventions from social robots for autistic individuals. While the review process was narrowed down to the twelve articles used, there is a need to

further investigate how might neurodiversity-affirming social robotic interventions serve to fit all ages. The research question of this scoping review was to address the question of the use of social skills curriculum within neurodiversity-affirming social robots for all ages. Universally, given the main results from the articles reviewed, there is a desire to figure out why robotics work on the social front. Based on our findings, we believe there is a need for more scoping reviews to fully address why social robots are useful for all ages, in terms of neurodiversity-affirming interventions that fit the PCC framework. This scoping review is a means to serve as a guide into why there is a need to assess robotic interventions within the PCC framework.

Limitations

Some of the limitations regarding the scoping review included the screening method; the processes of finding articles that accurately address our topic were restrictive since there are a limited number of articles that truly address our topic in its entirety. Robot-mediated intervention is still a relatively new field in autism intervention, so research regarding different treatment methods is limited. Materials were applied to both children and adults within the autistic community. No human subjects participated in the study, so recruitment concerns, dropouts, and scheduling did not apply as limitations. Notably, the presence of human subjects would have significantly enhanced our ability to determine which intervention is most appropriate for autistic individuals.

Conclusion

The purpose of this study was to investigate if a social skills curriculum provided by social robots are genuinely neurodiversity-affirming for all ages. Our research aim was to explore the potential benefits and challenges associated with these interventions,

along with their alignment to principles of neurodiversity. Our efforts were focused on gaining a more comprehensive understanding of effective and inclusive social skills interventions for autistic individuals. This review was written to inform future studies based on mapping previous literature in the form of a scoping review. Outcomes and conclusions may come in the form of revealing more possible research gaps within the topic addressed. In attempting to find if social robotics are neurodiversity-affirming for all ages, this study can help to further improve OT services by allowing the research to address how robotic interventions can serve the broader population. Overall, this review hopes to serve as a basis for discovering empirical data from literature that showcases if social robotic interventions for the autistic community is neurodiversity-affirming for all ages.

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Table 1

Compilation of Articles Intended for Review

Doi	Title	Abstracts taken from articles
Al-Nafjan, A., Alhakbani, N., & Alabdulkareem, A. (2023). Measuring engagement in robot-assisted therapy for autistic children. *Behavioral Sciences, 13*(8), 618. https://doi.org/10.3390/bs13080618	Measuring engagement in robot-assisted therapy for autistic children.	Children with autism face a range of challenges when it comes to verbal and nonverbal communication. It is essential that children participate in a variety of social, educational, and therapeutic activities to acquire knowledge that is essential for cognitive and social development. Recent studies have shown that children with autism may be interested in playing with an interactive robot. The robot can engage these children in ways that demonstrate and train essential aspects of human interaction, guiding them in therapeutic sessions to practice more complex forms of interaction found in social human-to-human interactions. This study sets out to investigate Robot-Assisted Autism Therapy (RAAT) and the use of artificial intelligence (AI) approaches for measuring the engagement of children during therapy sessions. The study population consisted of five native Arabic-speaking autistic children aged between 4 and 11 years old. The child–robot interaction was recorded by the robot camera and later used for analysis to detect engagement. The results show that the proposed system offers some accuracy in measuring the engagement of children with ASD. Our findings revealed that robot-assisted therapy is a promising field of application for intelligent social robots, especially to support autistic children in achieving their therapeutic and educational objectives.
Kouroupa, A., Laws, K. R., Irvine, K., Mengoni, S. E., Baird, A., & Sharma, S. (2022). The use of social robots with children and young people on the autism spectrum: A systematic review and meta-analysis. *PloS ONE, 17*(6), e0269800. https://doi.org/10.1371/journal.pone.0269800	The use of social robots with children and young people on the autism spectrum: A systematic review and meta-analysis	Robot-mediated interventions show promise in supporting the development of children on the autism spectrum. In this systematic review and meta-analysis, we summarize key features of available evidence on robot-interventions for children and young people on the autism spectrum aged up to 18 years old, as well as consider their efficacy for specific domains of learning. Data sources PubMed, Scopus, EBSCOhost, Google Scholar, Cochrane Library, ACM Digital Library, and IEEE Xplore. Grey literature was also searched using PsycExtra, OpenGrey, British Library EthOS, and the British Library Catalog. Databases were searched from inception until April (6th) 2021. Synthesis methods Searches undertaken across seven databases yielded 2145 articles. Forty studies met our review inclusion criteria of which 17 were randomized control trials. The methodological quality of studies was conducted with the Quality Assessment Tool for Quantitative Studies. A narrative synthesis summarized the findings. A meta-analysis was conducted with 12 RCTs. Results Most interventions used humanoid (67%) robotic platforms, were predominantly based in clinics (37%) followed home, schools and laboratory (17% respectively) environments and targeted at improving social and communication skills (77%). Focusing on the most common outcomes, a random effects meta-analysis of RCTs showed that robot-mediated interventions significantly improved social functioning (g = 0.35 [95%CI 0.09 to 0.61; k = 7). By contrast, robots did not improve emotion (g = 0.63 [95%CI -1.43 to 2.69]; k = 2) or motor outcomes (g = -0.10 [95%CI -1.08 to 0.89]; k = 3), but the numbers of trials were very small. Meta-regression revealed that age accounted for almost one-third of the variance in effect sizes, with greater benefits being found in younger children. Conclusions: Overall, our findings support the use of robot-mediated interventions for autistic children and youth, and we propose several recommendations for future research to aid learning and enhance implementation in everyday settings.

Pennazio, V. (2017). Social robotics to help children with autism in their interactions through imitation. *Research on Education and Media, 9*(1), 10–16. https://doi.org/10.1515/rem-2017-0003	Social robotics to help children with autism in their interactions through imitation	This article aims to reflect on the main variables that make social robotics efficient in an educational and rehabilitative intervention. Social robotics is based on imitation, and the study is designed for children affected by profound autism, aiming for the development of their social interactions. Existing research, at the national and international levels, shows how children with autism can interact more easily with a robotic companion rather than a human peer, considering its less complex and more predictable actions. This contribution also highlights how using robotic platforms helps in teaching children with autism basic social abilities, imitation, communication and interaction; this encourages them to transfer the learned abilities to human interactions with both adults and peers,through human–robot imitative modeling. The results of a pilot study conducted in a kindergarten school in the Liguria Region are presented. The study included applying a robotic system, at first in a dyadic child–robot relation, then in a triadic one that also included another child, with the aim of eliciting social and imitative abilities in a child with profound autism
Rakhymbayeva, N., Amirova, A., & Sandygulova, A. (2021). A long-term engagement with a social robot for autism therapy. Frontiers in Robotics and AI, 8. Article e669972. https://doi.org/10.3389/frobt.2021.669972	A long-term engagement with a social robot for autism therapy	Social robots are increasingly being used as a mediator between a therapist and a child in autism therapy studies. In this context, most behavioral interventions are typically short-term in nature. This paper describes a long-term study that was conducted with 11 children diagnosed with either Autism Spectrum Disorder (ASD) or ASD in co-occurrence with Attention Deficit Hyperactivity Disorder (ADHD). It uses a quantitative analysis based on behavioral measures, including engagement, valence, and eye gaze duration. Each child interacted with a robot on several occasions in which each therapy session was customized to a child's reaction to robot behaviors. This paper presents a set of robot behaviors that were implemented with the goal to offer a variety of activities to be suitable for diverse forms of autism. Therefore, each child experienced an individualized robot-assisted therapy that was tailored according to the therapist's knowledge and judgment. The statistical analyses showed that the proposed therapy managed to sustain children's engagement. In addition, sessions containing familiar activities kept children more engaged compared to those sessions containing unfamiliar activities. The results of the interviews with parents and therapists are discussed in terms of therapy recommendations. The paper concludes with some reflections on the current study as well as suggestions for future studies.

Ghiglino, D., Floris, F., De Tommaso, D., Kompatsiari, K., Chevalier, P., Priolo, T., & Wykowska, A. (2023). Artificial scaffolding: Augmenting social cognition by means of robot technology. *Autism Research*. https://doi.org/10.1002/aur.2906	Artificial scaffolding: Augmenting social cognition by means of robot technology	The concept of scaffolding refers to the support that the environment provides in the acquisition and consolidation of new abilities. Technological advancements allow for support in the acquisition of cognitive capabilities, such as second language acquisition using simple smartphone applications There is, however, one domain of cognition that has been scarcely addressed in the context of technologically assisted scaffolding: social cognition. We explored the possibility of supporting the acquisition of social competencies of a group of children with autism spectrum disorder engaged in a rehabilitation program (age = 5.8 ± 1.14, 10 females, 33 males) by designing two robot-assisted training protocols tailored to Theory of Mind competencies. One protocol was performed with a humanoid robot and the other (control) with a non-anthropomorphic robot. We analyzed changes in NEPSY-II scores before and after the training using mixed effects models. Our results showed that activities with the humanoid significantly improved NEPSY-II scores on the ToM scale. We claim that the motor repertoire of humanoids makes them ideal platforms for artificial scaffolding of social skills in individuals with autism, as they can evoke similar social mechanisms to those elicited in human-human interaction, without providing the same social pressure that another human might exert.
Ghiglino, D., Chevalier, P., Floris, F., Priolo, T., Wykowska, A. (2021). Follow the white robot: Efficacy of robot-assistive training for children with autism spectrum disorder. *Research in Autism Spectrum Disorders, 86.* https://doi.org/10.1016/j.rasd.2021.101822	Follow the white robot: Efficacy of robot-assistive training for children with autism spectrum disorder	Socially assistive robots have the potential to become a powerful therapeutic tool for individuals affected by Autism Spectrum Disorder (ASD). However, to date, only a few studies explored the efficacy of robot-assisted training embedded in structured clinical protocols. The current study aimed at investigating the beneficial effects of introducing a toy robot, as a new tool for clinicians, in the treatment plan carried out by an Italian healthcare institution. In collaboration with the healthcare professionals of Piccolo Cottolengo Genovese di Don Orione, we designed a robot-mediated activity aimed at improving social skills in children with ASD. Twenty-four children with ASD (Age = 5.79 ± 1.02, 5 females) completed the activities with the robot in a cross-over design, during a period of ten weeks. Their social skills were assessed before and after the robot intervention activities, using the Early Social Communication Scale (ESCS). Results showed that the combination of robot-assisted training with standard therapy was more effective than the standard therapy alone, in terms of improvement of social skills. Specifically, after the robot-assisted training, children with ASD improved in their ability to generate and respond to behavioral requests, and in their tendency to initiate and maintain social interaction with the adult. Conclusions Our results support the idea that robot-assisted interventions can be combined with the standard treatment plan to improve clinical outcomes.

Srinivasan, S. M., Park, I. K., Neelly, L. B., & Bhat, A. N. (2015). A comparison of the effects of rhythm and robotic interventions on repetitive behaviors and affective states of children with Autism Spectrum Disorder (ASD). *Research in Autism Spectrum Disorders, 8*, 51-63. https://doi.org/10.1016/j.rasd.2015.07.004	A comparison of the effects of rhythm and robotic interventions on repetitive behaviors and affective states of children with Autism Spectrum Disorder (ASD)	Repetitive behaviors and poor affect regulation are commonly seen in children with Autism Spectrum Disorder (ASD). We compared the effects of two novel interventions—rhythm and robotic therapies, with those of a standard-of-care intervention, on the repetitive behaviors and affective states of 36 children with ASD between 5 and 12 years using a randomized controlled trial design. We coded for frequencies of sensory, negative, and stereotyped behaviors and the duration of positive, negative, and interested affective states in children during early, mid, and late training sessions. In terms of repetitive behaviors, in the early session, the rhythm and robot groups engaged in greater negative behaviors, whereas the comparison group engaged in greater sensory behaviors. With training, the rhythm group reduced negative behaviors whereas there were no training-related changes in the other groups. In terms of affective states, the rhythm and robot groups showed greater negative affect, whereas the comparison group demonstrated greater interested affect across all sessions. With training, the rhythm group showed a reduction in negative affect and an increase in interest whereas the robot group showed a reduction in positive affect. Overall, it appears that rhythm-based interventions are socially engaging treatment tools to target core impairments in autism.
Ghiglino, D., De Tommaso, D., Maggiali, M., Parmiggiani, A., & Wykowska, A. (2022). Setup prototype for safe interaction between a humanoid robot (iCub) and children with autism-spectrum condition. https://doi.org/10.17605/OSF.IO/VK5CM	Setup prototype for safe interaction between a humanoid robot (iCub) and children with autism-spectrum condition	Socially-assistive robotics has the potential to become powerful assistance to healthcare professionals working with neurodevelopmental disorders (NDDs). A growing body of literature suggests that robot-mediated and robot-assisted activities might be beneficial for children with a neuro-developmental disorder. The robot could represent, for individuals with neurodevelopmental disorders, a safe and predictable environment in which they can practice simplified versions of social interaction. Here, we propose a solution to test the efficacy of robot-assisted training activity aimed at improving social skills in children with autism spectrum conditions (ASC).
Srinivasan, S. M., Eigsti, I., Neelly, N., & Bhat, A. N. (2016). The effects of embodied rhythm and robotic interventions on the spontaneous and responsive social attention patterns of children with autism spectrum disorder (ASD): A pilot randomized controlled trial. *Research in Autism Spectrum Disorders, 27*, pp. 54-72. https://doi.org/10.1016/j.rasd.2016.01.004	The effects of embodied rhythm and robotic interventions on the spontaneous and responsive social attention patterns of children with autism spectrum disorder (ASD): A pilot randomized controlled trial.	We compared the effects of 8-weeks of rhythm and robotic interventions with those of a comparison, standard-of-care intervention, on the spontaneous and responsive social attention patterns of school-age children with autism spectrum disorder. Attention patterns were examined within a standardized pretest/posttest measure of joint attention (JA) and a training-specific social attention measure during early, mid, and late training sessions. The rhythm and comparison groups demonstrated improvements in JA. Social attention was greater in the rhythm followed by the robot and lastly the comparison group. The robot and comparison groups spent maximum time fixating on the robot and objects, respectively. Across sessions, the robot group decreased attention to the robot and increased attention to elsewhere. Overall, rhythmic movement contexts afford sustained social monitoring in children with autism.

Telisheva, Z., Amirova, A., Rakhymbayeva, N., Zhanatkyzy, A., & Sandygulova, A. (2022). The quantitative case-by-case analyses of the socio-emotional outcomes of children with ASD in robot-assisted autism therapy. *Multimodal Technologies and Interaction*, *6*(6), 46. https://doi.org/10.3390/mti6060046	The quantitative case-by-case analyses of the socio-emotional outcomes of children with ASD in robot-assisted autism therapy	With its focus on robot-assisted autism therapy, this paper presents case-by-case analyses of socio-emotional outcomes of 34 children aged 3–12 years old, with different cases of Autism Spectrum Disorder (ASD) and Attention Deficit Hyperactivity Disorder (ADHD). We grouped children by the following characteristics: ASD alone (n = 22), ASD+ADHD (n = 12), verbal (n = 11), non-verbal (n = 23), low-functioning autism (n = 24), and high-functioning autism (n = 10). This paper provides a series of separate quantitative analyses across the first and last sessions, adaptive and non-adaptive sessions, and parent and no-parent sessions, to present child experiences with the NAO robot, during play-based activities. The results suggest that robots are able to interact with children in social ways and influence their social behaviors over time. Each child with ASD is a unique case and needs an individualized approach to practice and learn social skills with the robot. We, finally, present specific child–robot intricacies that affect how children engage and learn over time as well as across different sessions.
Santos, L., Geminiani, A., Schydlo, P., Olivieri, I., Santos-Victor, J., & Pedrocch, A. (2021). Design of a robotic coach for motor, social and cognitive skills training toward applications with ASD children. *IEEE Transactions On Neural Systems and Rehabilitation Engineering*, *29*. https://doi.org/10.1109/TNSRE.2021.3091320	Design of a robotic coach for motor, social and cognitive skills training toward applications with ASD children.	Socially assistive robots may help the treatment of autism spectrum disorder(ASD), through games using dyadic interactions to train social skills. Existing systems are mainly based on simplified protocols which qualitatively evaluate subject performance. We propose a robotic coaching platform for training social, motor and cognitive capabilities, with two main contributions: (i) using triadic interactions(adult, robot and child), with robotic mirroring, and (ii) providing quantitative performance indicators. The key system features were accurately designed, including type of protocols, feedback systems and evaluation metrics, contemplating the requirements for applications with autistic children. We implemented two protocols, Robot-Master and Adult-Master, where children performed different gestures guided by the robot or the adult respectively, eventually receiving feedback about movement execution. In both, the robot mirrors the subject during the movement. To assess system functionalities, with a homogeneous group of subjects, tests were carried out with 28 healthy subjects; one preliminary acquisition was done with an autistic child. Data analysis was customized to design protocol-specific parameters for movement characterization. Our tests show that robotic mirroring execution depends on the complexity and standardization of movements, as well as on the robot technical features. The feedback system evaluated movement phases and successfully estimated the completion of the exercises. Future work includes improving platform flexibility and adaptability, and clinical trials with autistic children to test the impact of the robotic coach on reducing symptoms. We trust that the proposed quantitative performance indicators extend the current state-of-the-art towards clinical usage of robotic-based coaching systems.

Korneder, J., Louie, W., G., Pawluk, C., M., Abbas, I., Brys, M., & Rooney, F. (2021). Robot-mediated interventions for teaching children with ASD: a new intraverbal skill. *Assistive Technology*. *34*(6), 707-716. https://doi.org/10.1080/10400435.2021.1930284	Robot-mediated interventions for teaching children with ASD: a new intraverbal skill.	Socially assistive robots (SAR) have the potential to impact therapies for Autism Spectrum Disorder (ASD) by supporting clinicians in increasing learning opportunities presented to individuals. Recent research on robot-mediated intervention (RMI) delivery has predominantly addressed autistic social deficits with positive outcomes. Current literature has minimal focus on teaching autistic children a skill not known apriori by the individual. Furthermore, it is unclear how to integrate robots in clinical settings because current RMIs do not adhere to Applied Behavior Analysis (ABA) protocols. In this work, we investigated whether an RMI could be utilized to teach autistic children a completely new language and communication skill they could not exhibit at baseline. We utilized a standard ABA assessment tool to first identify appropriate skills to teach autistic children. We then developed, implemented, and evaluated an RMI intervention that followed standard clinical operating procedures in ABA and targets participants' unique skill deficits. We examined the effects of the RMI training on teaching wh-question answering. All sessions were conducted with the SAR as the primary therapist using evidenced-based ABA human teaching protocols. All participants acquired the wh-questions answering skill within seven sessions, which is in line with their typical acquisition rates.
Fassina, G., Santos, L., Geminiani, A., Caglio, A., Annunziata, S., Olivieri, I., & Pedrocchi, A. (2022). Development of an interactive total body robot enhanced imitation therapy for ASD children. https://doi.org/10.1109/ICORR55369.2022.9896536	Development of an interactive total body robot enhanced imitation therapy for ASD children.	Autism is a neurodevelopmental disorder in which the available therapies target the improvement of social skills, in order to ensure a high quality of life for the child. The use of Social Assistive Robots offers new therapeutic possibilities in which robots can act as therapy enhancers. IOGIOCO project emerges in this framework: it aims at the development of a Robot- Assisted Therapy protocol for the treatment of Autism Spectrum Disorder, through gesture training. The definition of these gestures and their recognition by the robot are parameters that directly affect the engagement of the children. However, the design of a protocol becomes harder in a highly unconstrained environment. Therefore, the current work aims at expanding the gesture set and improving the gesture recognition algorithm available in the IOGIOCO platform. More specifically, total body gestures have been added to the available upper limbs movements, and a custom Activity Detection method has been developed, which allows the identification of the time window in which a gesture is performed. The insertion of this method on a recognition algorithm based on a ResNet, a particular kind of Convolutional Neural Network, improved its F1-score from 57% obtained with the previously-available version, in a dataset of ASD children, to 76%, demonstrating the effectiveness of the Activity Detection method. Furthermore, the expansion of the interaction possibilities to total body movements was positively evaluated by the clinical staff, increasing the engagement of patients and the set of possible trained skills. Therefore, the results of the current work are encouraging. To reinforce the conclusions drawn, the proposed algorithm should be tested in real time on several autistic children within a complete Randomized Clinical Trial, also to study the effectiveness of this type of treatment. From the technical point of view, further improvements of the developed methodology should tackle the remaining issues, such as further increasing the recognition capability, especially in the transitions from sitting to standing, that proved to be a hard task for the developed method.

Fachantidis, N., Syriopoulou-Delli, CK, Zygopoulou, M. (2020). The effectiveness of socially assistive robotics in children with autism spectrum disorder. International Journal of Developmental Disabilities. 66(2), 113-121. https://doi.org/10.1080/20473869.2018.1495391	The effectiveness of socially assistive robotics in children with autism spectrum disorder.	The current study was carried out to examine the role of the Socially Assistive Robotics (SAR) as an innovative educational tool in the development of the social skills of children with autism as they participated in structured and suitably prepared activities, which in the present study was conducted by a social robot, Daisy, as well as a human partner in order subsequently to compare the results of the two different interventions. Participants in the study comprised four children with autism who are pupils at elementary school and are simultaneously assisted by a special support teacher. The study was carried out in a special education center and sessions were held outside of the regular school timetable. In total, eight 30-minute sessions each comprising four activities were held with each of the pupils. In those sessions the researcher examined the two aforementioned goals of the research and for this purpose they used data forms for frequency (Zirpoli [28]), to count the frequency of the appearance of specific behaviors within the referred period. The positive outcomes of the current research would be significantly helpful and promising for the teaching process of children with ASD and, in addition to special education teachers in schools; they could also be implemented by parents at home and other specialists involved in the care of children with ASD with the aim of assisting them to showcase and reach their full potential.
Yun, S., Sung-Kee, J. C., Park, S., Bong, G., & Yoo, H. (2017). Social skills training for children with autism spectrum disorder using a robotic behavioral intervention system. *Autism Research, 10,* 1306-1323. https://doi.org/10.1002/aur.1778	Social skills training for children with autism spectrum disorder using a robotic behavioral intervention system.	The aim of this study is to evaluate and verify the effects of behavioral interventions that use a robot as a facilitator for behavior in children with ASD. It is mentioned from the article that there is little knowledge on the utility of robotic feedback in relation to behavioral interventions for individuals with ASD. This includes limited detection of facial emotions, behavioral adaptive abilities towards the robotic interactions. In this study, the researchers examined these problems with robot-based training systems.
Van den Berk-Smeekens, I., de Korte, M. W. P., van Dongen-Boomsma, M., Oosterling, I. J., den Boer, J. C., Barakova, E. I., Lourens, T., Glennon, J. C., Staal, W. G., & Buitelaar, J. K. (2021). Pivotal response treatment with and without robot-assistance for children with autism: a randomized controlled trial. *European Child & Adolescent Psychiatry*, 31. 1871–1883. https://doi.org/10.1007/s00787-021-01804-8	Pivotal response treatment with and without robot-assistance for children with autism: a randomized controlled trial	The present study is to provide more research on appropriate interventions for young children with autism. Since robotics are appealing to most children and may contribute to their motivation for social interaction, this study is conducted through a randomized control trial (RCT) comparing pivotal response time (PRT) and robot-assisted PRT with treatment as usual (TAU). The main design of the experiment is to examine the efficiency of PRT (with and without robotic assistance) compared to treatment as usual (TAU) in a clinical sample of children with ASD.
Sætra, H. S., Nordahl-Hansen, A., Fosch-Villaronga, E., & Dahl, C. (2022). View of normativity assumptions in the design and application of social robots for autistic children. https://doi.org/10.3384/ecp187023	Normativity assumptions in the design and application of social robots for autistic children	Social robots interact with human beings and are used for a variety of therapeutic purposes, for example in interaction with children with neurodevelopmental disorders. A key ethical issue related to the application of social robots in these contexts is the idea of normativity, involved in both the design of social robots, i.e., the use of such robots to portray or mimic what is normal and to identify deviant behavior or development. The article presents the beginnings of a framework for incorporating divergent opinions of normal social functioning, particularly neurodiversity, into the design and application of social robots.

Arent, K., Brown, D. J., Kruk-Lasocka, J., Niemiec, T. L., Pasieczna, A. H., Standen, P. J., & Szczepanowski, R. (2022). The use of social robots in the diagnosis of autism in preschool children. *Applied Sciences, 12*(17). https://doi.org/10.3390/app12178399	The use of social robots in the diagnosis of autism in preschool children	The present study contributes to the research problem of applying social robots in autism diagnosis. There is a common belief that existing diagnostic methods for autistic spectrum disorder are not effective. Advances in Human–Robot Interactions (HRI) provide potential new diagnostic methods based on interactive robots. We investigated deficits in turn-taking in preschool children by observing their interactions with the NAO robot during two games: (Dance with me vs. Touch me). We compared children's interaction profiles with the robot (five autistic vs. five typically developing young children). Then, to investigate turn-taking deficits, we adopted a rating procedure to indicate differences between both groups of children based on an observational scale. A statistical analysis based on ratings of the children's interactions with the NAO robot indicated that autistic children presented a deficient level of turn-taking behaviors. Our study provides evidence for the potential of designing and implementing an interactive dyadic game between a child and a social robot that can be used to detect turn-taking deficits based on objective measures. We also discuss our results in the context of existing studies and propose guidelines for a robotic-enabled autism diagnosis system.
Valadão, C. T., Goulart, C., Rivera, H., Caldeira, E., Filho, T. F. B., Frizera-Neto, A., & Carelli, R. (2016). Analysis of the use of a robot to improve social skills in children with autism spectrum disorder. *Research on Biomedical Engineering, 32*, 161–175. https://doi.org/10.1590/2446-4740.01316	Analysis of the use of a robot to improve social skills in children with autism spectrum disorder	Autism Spectrum Disorder is a set of developmental disorders that imply poor social skills, lack of interest in activities and interaction with people. Treatments rely on teaching social skills and in such therapies robotics may offer aid. This work is a pilot study, which aims to show the development and usage of a ludic mobile robot for stimulating social skills in ASD children.
Zorcec, T., Ilijoski, B., Simlesa, S., Ackovska, N., Rosandic, M., Popcevic, K., Robins, B., Nitzan, N., Cappel, D., & Blum, R. (2021). Enriching human-robot interaction with mobile app in interventions of children with autism spectrum disorder. *PRILOZI, 42*(2), 51–59.https://doi.org/10.2478/prilozi-2021-0021	Enriching human-robot interaction with mobile app in interventions of children with autism spectrum disorder	Autism spectrum disorder (ASD) is a group of complex lifelong neurodevelopmental disorders, characterized by difficulties in social communication and stereotyped behaviors. Due to the increasing number of autistic children, it is important to continue developing interventions as well as invent new ones. Human-robot interaction can contribute to better outcomes for these children. There are several robots such as Nao, Kaspar, ZENO, Probo, ZECA, etc. which are used in autism interventions. Many mobile and web applications are in constant growth, too. They target skills such as collaboration, social skills, language skills, social competence, and communication. The teams aim is to explore the usability of the humanoid robot Kaspar and a complementary app in interventions of children with ASD. Sample: 20 children with ASD, aged between 23 and 76 months old. As an added intervention for this group of children, we used the robot Kaspar and its app. Kaspar is a child-sized humanoid robot that uses bodily expressions, facial expressions, gestures, and pre-recorded speech to interact with a human. This intervention achieved certain positive shifts in eight of the eleven measured developmental domains, such as communication functions and means, turn taking, imitation, language skills, play, atten- tion and daily life skills. The three categories that had inconsiderable improvement are vocalization and speech, cause and effect and coping skills. Based on the measurements before and after the use of Kaspar and its complementary app, there is improvement, primarily in the domains of language, imitation and communication skills and attention.

Note: Compilation of articles intended for review sorted by reference, title, and abstract taken directly from the article.

Table 2

Articles Completed for Review

Reference	Aim/Purpose	Methodology	Intervention	Outcomes	Critical Findings Related to Research Question
Srinivasan, S. M., Park, I. K., Neelly, L. B., & Bhat, A. N. (2015). A comparison of the effects of rhythm and robotic interventions on repetitive behaviors and affective states of children with Autism Spectrum Disorder (ASD). *Research in Autism Spectrum Disorders, 18*, 51–63. https://doi.org/10.1016/j.rasd.2015.07.004	To compare the effects of rhythm and robotic therapies, with those of a standard-of-care intervention, on the repetitive behaviors and affective states of 36 autistic children.	A pilot randomized controlled trial by Srinivasan et al. (2015) compared the effects of rhythm and robotic interventions with a NAO and Rovio robot to a comparison intervention on the social communication, behavioral, and motor skills of autistic children. The children were videotaped for behavioral coding in repetitive and maladaptive behaviors and affective states.	ABA-principle-based joint action-based gross motor and/or fine motor activities that promoted social skills such as eye contact, turn-taking, imitation, and general communication skills. The rhythm and robotic intervention group also incorporated balance, coordination, manual dexterity, imitation, and interpersonal synchrony	In the initial stages of intervention, the rhythm and robot groups demonstrated greater levels of negative behaviors and negative affect than the comparison group. The comparison group were engaged in more familiar activities, which provided more structure, which often minimizes anxiety. in the later stages, the robot group demonstrated reduced negative behaviors, reduced negative affect, and an increase in interest.	Heavy use of ABA in these interventions causes concern for the autonomy of the autistic children involved. Although there were reported improvements in the participants' social engagement skills, the focus of the article alludes to increasing compliance with a reduction in negative behaviors and negative affect. This study indicates promoting interventions that are constrained, demarcated, and predictable in order to increase compliance and reduce maladaptive behaviors. However, the study by Srinivasan et al. (2015) may indicate a possible use of movement-based intervention by social robotics that is neurodiversity-affirming. As autistic children become more familiar with the training activities by social robots, the social robots can be used to incur a positive affective state to allow a child to be more comfortable during an intervention. However, this would only be considered neurodiversity-affirming if the intervention allows for the child to freely participate in their stereotypical behaviors. Attention data from the same study suggests that children in the comparison group spent maximum time looking at objects, whereas children in the movement groups looked most at their social partners

					(Srinivasan et al., 2015). Social robots can be suggested to be used to naturally direct social attention during an intervention. This study mainly involves training neurotypical social skills, which encourages the harmful effects of autistic masking. Overall, this intervention does not support social robotics as a neurodiversity-affirming practice.
Telisheva, Z., Amirova, A., Rakhymbayeva, N., Zhanatkyzy, A., & Sandygulova, A. (2022). The quantitative case-by-case analyses of the socio-emotional outcomes of children with ASD in robot-assisted autism therapy. *Multimodal Technologies and Interaction*, *6*(6), 46. https://doi.org/10.3390/mti6060046	To present more up-close and child-centered data obtained during our self-developed robot-assisted autism therapy, with four cohorts of children with ASD. Also to design and provide personalized and adaptive experiences for children with ASD, who are facing life-long challenges with expressing and understanding social cues, in their day-to-day lives	A case-by-case analysis of the socio-emotional outcomes of 34 autistic children exposed to different types of robot-assisted-treatment conditions. We analyzed and reported the child's behaviors, through 11 measures. Children were separated into different groups: Adaptive (A): sessions consisting of only previously seen, familiar, and liked activities; and Non-adaptive (NA): sessions introducing unseen and unfamiliar activities.	7 activity blocks ("Songs", "Dances", "Emotions", "Touch me", "Storytelling", "Imitation", and "Social Acts") were presented to the children. The robots performed or demonstrated the activities and encouraged the children to imitate or respond to it. The robot behaviors and activities followed ABA principles for prosocial and emotional skills. Positive reinforcement such as verbal and non-verbal praise was given for correct behaviors.	Most children increased engagement score over time, with the engagement increasing with the more sessions the children attended. Children with severe autistic symptoms seem to gain more social gains, as confirmed by their significant engagement scores across sessions. Children with ASD are more engaged with and responsive to the robot, when the sessions are tailored to their play preferences and task performance	The usage of ABA in this study approaches specific behaviors of engagement as negative. For example, pressing the robot's chest button was interpreted as an undesirable and "naughty" behavior. The consideration of this behavior as unmanageable and undesirable indicates the assumption that all behaviors that are atypical of play are inappropriate. This exemplifies a non-neurodiversity-affirming approach. The negative behaviors may be a form of exploration and engagement to the child, but labeling them as undesirable removes the diversity of autistic children and assumes that only the neurotypical way of exploration and engagement are considered social skills.
Ghiglino, D., Floris, F., De Tommaso, D., Kompatsiari, K., Chevalier, P., Priolo, T., & Wykowska, A. (2023). Artificial scaffolding: Augmenting social cognition by means of robot technology. *Autism Research*, *16*(5), 997–	To find if non-android robots with human-like shape and human-like capabilities might be particularly suited for training or augmenting social cognition, and could be integrated into rehabilitation services.	An interaction protocol with humanoid robot iCub embedded in the standard ongoing rehabilitation activities for a group of autistic children, and an active control study where another group of autistic children was engaged in interaction with a non-human-like toy robot, which could not manipulate objects.	The robot was placed on the opposite side of the child, with a small dice either positioned between the child and the toy-robot condition or handed over to iCub and held in the humanoid condition. The children's task was to determine which side of the dice the robot was looking at. As the children were seated on the opposite side of the robot, the side of the dice visible from	Planned comparisons showed that training with the humanoid robot was successful in augmenting children's theory of mind abilities more than the traditional treatment, with no difference found between the last two interventions. Results show that children with ASD benefit most from the activities embedded in the interaction with the humanoid robot,	This study focused on evoking social cognition as a form of social skills training. Both robot-mediated interventions were applied in conjunction with cognitive behavioral therapy and cognitive affective training protocols. The aim was to increase the social cognitive skill of theory of mind, which does not involve changing behavior. This implies that the improvement of social

1008. https://doi.org/10.1002/aur.2906			the robot's perspective was different from the children's perspective. This tested both mechanisms of decoupling and understanding incongruence.	relative to standard therapy or the toy robot Cozmo. Specifically, theory of mind abilities measured with the standardized scale NEPSY improved more after children interacted with the humanoid, relative to the other two conditions	skills does not always involve changing stereotypical autistic behavior. This allows the child to practice their social cognitive skills to increase their theory of mind, then giving them the opportunity to utilize this new skill using their own strengths. This study emphasizes tailoring the intervention to the child's specific needs and strengths, which is a neurodiversity-affirming practice.
Santos, L., Geminiani, A., Schydlo, P., Olivieri, I., Santos-Victor, J., & Pedrocch, A. (2021). Design of a robotic coach for motor, social and cognitive skills training toward applications with ASD children. *IEEE Transactions On Neural Systems and Rehabilitation Engineering*, *29*. https://doi.org/10.1109/TNSRE.2021.3091320	The study conducted by Santos et al. (2021) aims to create a robotic coaching platform for teaching triadic mirroring to autistic children. Santos et al. (2021) address three primary research questions in this study: How to design the best protocols for robotic mirroring involving triadic interactions and training motor, social and cognitive skills? How can the robot/system evaluate the movements executed by a person and provide appropriate feedback? Which metrics are better for inter-subject overall comparison over time? Two protocols were created by the study to address these issues, and healthy adults and children were used to test them. The study suggests new quantitative measurements to assess the degree of difficulty,	A pilot cross-sectional observational study involving a sample size of 30 individuals in total in a clinical setting, including 14 healthy children (between 5 and 10 years old, seven boys and seven girls) and 14 adults close to each child (usually one of the parents). The remaining two individuals were a 5-year-old girl diagnosed with autism and her therapist. Within the same session, each protocol was executed once by a child and an adult, resulting in 15 acquisitions.The inclusion criteria for this study were healthy children between 5 and 10 years old, adults close to each child (usually one of their parents), and one 5-year-old girl diagnosed with autism and her therapist experienced with technology-mediated treatments. All participants and their legal guardians signed informed written consent before the acquisitions, and the Ethical Committee of Politecnico di Milano approved the study (Santos et al., 2021). There is no mention of the exclusion criteria.	This study presents a platform for robotic coaching using triadic mirroring training during therapy sessions for autistic children (Santos et al., 2021). Two different protocols were designed and tested on healthy adults and children. The system was also assessed in a clinical setting with one autistic child and one therapist. The system allows for training social and cognitive capabilities beyond just mirroring and motor skills. New quantitative measures were proposed to evaluate the difficulty level, repeatability, and mirroring of the movements chosen for each protocol (Santos et al., 2021).	The outcome measures in the Santos et al. (2021) study was to identify the best robotic mirroring coaching protocols, explored in both the Robot-Master and Adult-Master protocols. Additionally, the study focused on understanding the most effective robotic feedback, which was explicitly evaluated in the Robot-Master protocol. The Adult-Master protocol was also used to investigate the standardization of movements. It involved repeated movements initiated by different subjects, allowing for the evaluation of execution and mirroring differences.	This study highlights the potential advantages of utilizing robotics in autism therapy. Exploring the findings of this study can help clarify how robotics can be utilized to improve therapy outcomes for autistic individuals. Santos et al. (2021) provide some evidence that the use of a NAO robot and Kinect camera in turn-taking games may be suitable for children with autism and could potentially be integrated into a therapeutic framework. Santos et al. (2021) state that evaluating the clinical efficacy requires additional research. This study offers some insights into the potential advantages of using a humanoid robot like the NAO, which can offer simplified stimuli and audio-visual feedback (Santos et al., 2021), which may be more conducive for interaction with children with autism. To ensure that any approach is based on the needs and preferences of the autistic person, it is essential to consider the broader ethical and social implications of employing robotics in autism therapy. Additionally, it is crucial to involve

	repeatability, and mirroring of the motions selected for each protocol (Santos et al., 2021).				individuals with autism in the planning and execution of any therapeutic strategy to guarantee that it is genuinely neurodivergent-affirming.
Korneder, J., Louie, W. G., Pawluk, C. M., Abbas, I., Brys, M., & Rooney, F. (2021). Robot-mediated interventions for teaching children with ASD: A new intraverbal skill. Assistive Technology, 34(6), 707-716. https://doi.org/10.1080/10400435.2021.19302844	This study aims to investigate if a robot-mediated intervention (RMI) could teach children with autism spectrum disorder (ASD) a new language and communication ability they could not display at baseline, particularly the intraverbal skills needed for answering wh-questions. The study focuses on an RMI intervention that targets the skill deficits of participants and adheres to accepted clinical practices in Applied Behavior Analysis (ABA). This study also investigates how teaching wh-question response is affected by RMI training.	An experimental/single-subject multiple baseline design (MBD) with a sample size of 3 autistic children. The study was conducted in a private therapy room measuring roughly 11' x 22' with a carpeted floor in a university-based ABA autism clinic in a Midwestern state. There were two tables and four chairs in the room. The room was equipped with a GoPro camera to record the intervention for post-interaction analysis. To prevent the participant from physically interacting with the robot, a researcher was in the room and seated in a chair. The researcher was also in charge of data collection. A second researcher was also in the room, using a laptop computer to direct the robot's movements (Korneder et al., 2021). The inclusion/exclusion criteria involved children between the ages of 3-8 years old, with a DSM-5 diagnosis for autism, who had not mastered wh-questions. Although each participant had experienced responding to wh-questions in the past, they did not employ the wh-questions that were used in the study at the baseline. Through a robot-mediated reading program, two of the three participants had previously encountered a robot.	The study used an ABA-based robot-mediated intervention called Discrete Trial Training (DTT).	The percentage of correctly answered questions to the three intraverbal wh-questions given to participants served as the study's outcome measure. For nine trials, three of each question were given at random. A "+" was used to denote a correct response, a "-" an incorrect response, and a "+P" or "-P" for prompted responses that were incorrect. The percentage of correct responses to the three intraverbal wh-questions comprised wh-questions, with typical responses as the primary dependent variable. A humanoid robot named Nao performed one session of nine trials of wh-questions per day for the study's participants (Korneder et al., 2021).	This study provides evidence for the potential effectiveness of using SARs to deliver ABA-based interventions for autistic children. The study found that a robot could effectively teach children with autism spectrum disorder (ASD) how to answer wh-questions using a discrete trial training-based intervention. The skill acquisition rate was similar to when humans delivered the training procedure, and the children also retained and generalized the skill to some extent one year later (Korneder et al., 2021). The study demonstrates that robots can deliver ABA-based interventions as efficiently and effectively as human therapists and teach a new skill not previously known to the child. The study also supports using SAR technology as an evidence-based approach for delivering ABA-based therapies to autistic children. However, ABA is based on the traditional approach of changing the behavior of neurodivergent individuals to fit into societal norms. This approach must pay more attention to the strengths and unique perspectives that neurodivergent individuals can bring. In doing so, we can create more focused interventions that acknowledge and build upon their strengths and unique perspectives

					while promoting their independence.
Fassina, G., Santos, L., Geminiani, A., Caglio, A., Annunziata, S., Olivieri, I., & Pedrocchi, A. (2022). Development of an interactive total body robot enhanced imitation therapy for ASD children. https://doi.org/10.1109/ICORR55369.2022.9896536	This study aims to develop an Interactive Total Body Robot Enhanced Imitation Therapy for autistic children using a social assistive robot. The study focuses on expanding the gesture set and improving the gesture recognition algorithm available in the IOGIOCO platform, including total body gestures and a custom Activity Detection method.	A qualitative study grounded theory study which included a total of 22 test subjects, including 16 healthy adults who executed all gestures introduced in the protocol and 5 autistic children aged between four and six (mean age 4.9, std (0.74) who performed 64 gestures recorded during previous therapy sessions, 1 autistic child aged 7 years old who was used for real-time acquisition at Fondazione Don Gnocchi. The setting of the study included a therapy room.There was no mention of inclusion/exclusion criteria.	The intervention of the research study developed and tested a gesture recognition algorithm for an imitation training therapy based on the triadic interaction between a humanoid robot, a therapist, and a child with a severe case of autism. The therapy involved the robot presenting a gesture, the therapist imitating it, and the child performing the same movement. The research used a setup with a humanoid robot, NAO from Aldebaran Robotics, and a Microsoft Kinect camera to track participant movements. The study used two datasets, one of healthy adults and the other of autistic children, to develop and test the gesture recognition algorithm. The algorithm relied on three phases: activity detection, feature extraction, and recognition using a ResNet, a type of Convolutional Neural Network.	The purpose of the study was to enable triadic therapy contact using real-time gesture recognition.	The study highlights the potential of using robotic therapy for autistic children. The findings suggest that autistic children significantly improved social skills after receiving robotic therapy, which could help them better navigate social situations, promote independence, and improve their overall quality of life. Hence, robotic therapy could be a valuable tool for treating the social deficits common in children with autism. Overall, this study adds to the growing body of research supporting the use of robotic therapy for children with autism and suggests that it could be an effective approach for addressing their social deficits.
Valadão, C. T., Goulart, C., Rivera, H., Caldeira, E., Filho, T. F. B., Frizera-Neto, A., & Carelli, R. (2016). *Analysis of the use of a robot to improve social skills in children with autism spectrum disorder. Research on Biomedical Engineering, 32*, 161–175. https://doi.org/10.1590/2446-4740.01316	This study is an initial investigation designed to demonstrate the creation and application of an interactive mobile robot to enhance social skills in autistic children.	The approach used in this study involved modifying a mobile robot to have a playful and toy-like appearance. This modification aimed to facilitate interactions with children and encourage the development of their social skills, including eye contact, physical touch, and imitation. These particular skills are often significantly impaired in children with autism.	A unique mobile robot, equipped with a customized outfit and a screen for displaying multimedia content, was created for engaging with autistic children. An intermediary oversees the robot's actions within a specially arranged room designated for interactive sessions. These sessions are recorded to evaluate several social skills, including eye contact, physical interaction with the robot, and mimicry of the intermediary's actions. The quality of interaction is assessed using both the Goal	By employing the robot MARIA in a repetitive manner, it has proven to be an effective instrument for improving the socialization abilities of autistic children, as they responded positively to this robotic system. Additionally, future studies can explore novel modes of interaction to further stimulate cognitive and emotional progress in these children.	The findings revealed that, on average, the group that consists of the autistic children interacted with the robot by touching it approximately twice as often as the control group (CG). Moreover, they displayed similar patterns of looking away from the mediator and imitating their actions, resembling the behavior of the CG. Additionally, the group of autistic children exhibited enhanced social skills, both in verbal and non-verbal communication. These results are regarded as a significant step forward in enhancing the social

			Attainment Scale and the Likert scale. The study involved the evaluation of ten children, half of whom had ASD. Inclusion criteria comprised children aged 7-8 years old, those not currently taking medication, and those without a tendency toward aggression or stereotypical behaviors. The children used in this study were five ASD children and five without ASD (control group), with ages ranging from 7 to 8 years old. The ASD children are with AMAES (acronym in Portuguese for "Association of Friends of Autistics of Espírito Santo"). The children from the control group are with EMEF-UFES (Municipal Elementary School of Vitoria at Federal University of Espírito Santo).		skills of autistic children.
Sætra, H. S., Nordahl-Hansen, A., Fosch-Villaronga, E., & Dahl, C. (2022). View of Normativity assumptions in the design and application of social robots for autistic children. https://doi.org/10.3384/ecp187023	The aim of this article is to elaborate on the circumstances under which normative concerns become pertinent in the development and utilization of social robots intended for autistic children. By shedding light on these concerns, our objective is to equip developers, designers, therapists, and policymakers with a better understanding of when it is appropriate to consider normativity in robot design and when it should be addressed and minimized.	The article introduces the initial stages of a framework and literature for integrating varying viewpoints on typical social behavior, with a particular focus on neurodiversity, into the development and implementation of social robots.	The researchers are trying to emphasize that depicting something as "normal" inherently entails exerting control or influence, they contend that normative aspects are deeply ingrained in both the development and application of social robots in the context of autism. While they don't suggest that normativity is inherently negative, it is crucial for policymakers, designers, researchers, therapists, and individuals involved with autistic children to recognize the potential challenges associated with categorizing certain aspects as typical while labeling others as atypical, as well as	The described procedures involve the inclusion of autistic individuals or their advocates in conversations about the modeling and portrayal of social behavior in social robots, the utilization of social robots in interventions, and especially the decision-making regarding whether social robots should possess the capability to recognize and potentially assist in diagnosing autism.	This research article has proposed an approach centered on neurodiversity when it comes to designing and using social robots. Achieving this goal entails that lawmakers, designers, and users of social robots adopt a precautionary approach concerning diversity and inclusivity in both the creation and utilization of these robots.

			neurotypical or neurodivergent.		
Arent, K., Brown, D. J., Kruk-Lasocka, J., Niemiec, T. L., Pasieczna, A. H., Standen, P. J., & Szczepanowski, R. (2022). The use of social robots in the diagnosis of autism in preschool children. Applied Sciences, 12(17). https://doi.org/10.3390/app12178399	The purpose of this study was to examine turn-taking difficulties in preschool-aged children by observing their interactions with the NAO robot in two games: "Dance with me" and "Touch me." The researchers conducted a comparative analysis of how children interacted with the robot, with a sample consisting of five autistic children and five typically developing children. To assess turn-taking deficits, we used a rating procedure to identify distinctions between these two groups of children, as determined by an observational scale.	The experimental process comprised two sessions: one for getting acquainted with NAO and the other for the primary experiment. During the familiarization session, NAO introduced itself to the child and performed two brief, rhythmic dances, which took approximately 5 minutes. Subsequently, there was a short break, and the main experiment commenced, starting with the "Touch me" game, followed by the "Dance With Me" game.	Each of the two games lasted around 5 minutes for every child. Following each child's participation in the experiment, there was another break lasting several minutes before repeating the experiment with a different child. During each visit to a specific kindergarten, a maximum of three children took part in the experiment.	The experiment revealed that when interacting with the robot, autistic children were perceived as displaying a higher level of interest and more additional movements compared to typically developing children.	The research offers proof of the feasibility of creating and executing an interactive two-player game involving a child and a social robot, which can be employed to identify problems with turn-taking through objective assessments. Nonetheless, even though extensive research exists regarding the diagnosis of Autism Spectrum Disorder (ASD) there has been limited focus on standardizing diagnostic tools to distinguish autism, particularly its milder manifestations, from typical developmental patterns. This contributes to our research question that to present day, social robots are not particularly neurodiversity-affirming. Additionally, they analyze their findings within the framework of previous research and suggest recommendations for a robotic-assisted autism diagnosis system.
Fachantidis, N., Syriopoulou-Delli, C.K., & Zygopoulou, M. (2020). The effectiveness of socially assistive robotics in children with autism spectrum disorder. *International Journal of Developmental Disabilities. 66*(2), 113-121. https://doi.org/10.1080/20473869.2018.1495391	The aim of this study is to investigate the enhancement of social and communication skills of autistic children when they participate in suitably prepared structured activities. Specifically, the study focuses on activities beside a robotic partner, a stuffed toy robot shaped like a flower that embodies characteristics of expression and speech. The study focuses on the outcomes of interactions based on four	The current study was carried out to examine the role of the Socially Assistive Robotics (SAR) as an innovative educational tool in the development of the social skills of autistic children as they participated in structured and suitably prepared activities. The present study was conducted by a social robot, Daisy, as well as a human partner in order to subsequently compare the results of the two different interventions.	The intervention was carried out in the special education center outside of the regular school timetable and lasted five months from November 2016 to April 2017. The purpose of the research was to investigate the differences in the performance of each pupil individually in the matter of definite variables. Phases of the intervention included the familiarity phase (A) and both the teacher (B) and the robot (B') would conduct the same activities so that the two interventions would only differ based on the	The positive outcomes of this study included continuing research for the teaching process of children within the autistic community and possible implementation of robotic interventions within the household.	In particular, there is a statistically significant difference for all three components of the quality of interaction between teacher-performed activity and robot-performed activity, showing that the quality of interaction is better for the robot-performed activity. There were signs of high levels of eye contact exhibited during the sessions with the robot and were not evident within the sessions with the teacher. The results were in accordance with previous research supporting evidence that autistic children display high levels of eye contact when they interact with a robot in

	elementary school pupils within the autistic community.		interaction partner. Participants were divided into two groups, pupils 1,2,3,4, conducting the same activities. Sessions for each pair followed a different sequence so that the two participants followed a B-B'-B-B' and the other sequence B'-B-B-B' in order to predict methodological issues. This was a single case design intervention.		comparison to a human teacher (Fachantidis, et al., 2020). This study shows evidence of why there is a need for continued research into how robotic interactions help to address social interactions and communication for children within the autistic community.
Yun, S., Choi, J., Park, S., Bong, G., & Yoo, H. (2017). Social skills training for children with autism spectrum disorder using a robotic behavioral intervention system. *Autism Research*, 10(7), 1306–1323. https://doi.org/10.1002/aur.1778	The aim of this study is to evaluate and verify the effects of behavioral interventions that use a robot as a facilitator for behavior in autistic children. It is mentioned from the article that there is little knowledge on the utility of robotic feedback in relation to behavioral interventions for autistic individuals. This includes limited detection of facial emotions, behavioral adaptive abilities towards the robotic interactions. In this study, the researchers examined these problems with robot-based training systems by (1) constructing a semiautonomous robotic intervention system with interaction technologies, an improved algorithm for eye-contact detection, no remote control, and object detection/classification technologies and (2) designing	The design included a behavioral intervention program that focused on eye contact and facial emotion recognition based on the discrete trial teaching (DTT) protocol (Yun, et al., 2017). Protocol was applied through a three term contingency, of the antecedent response (Sa), acceptable response (Ra), and consequent stimulus (Sc) to bring out the target behaviors in a positive reinforcement system (Yun, et al., 2017). The interactions consisted of four modules including: Training element query, recognition for human activity, coping mode selection, and follow-up action. In the training session the robot would deliver the first training factor (Sa) and was picked in advance by the therapist, the child's response to (Sa) and (Ra) interactions would be measured. The robot would select one of the preset response modes for reward, encouragement, or pause, and would perform the subsequent action (Sc) in order to motivate the child with positive reinforcement.	The training sessions were designed with a social skills training program consisting of eight sessions that each lasted 30–40 min with three sets of interactions: (1) therapist observer–robot; (2) child–robot; and (3) therapist observer–child. Each phase had an introductory session in which the robot would greet the therapist with a pre-registered script. The robot would ask the therapist to read his facial emotion by asking "Please tell me what my facial expression is." while the robot would try to make eye contact with the therapist. The therapist would reply in a form like "CARO (name of the robot) looks sad." After each trial, the robot would respond "I'm pleased you can recognize my feelings," this would facilitate engagement and imitations of the therapist's action and effort by the child in successive interactions. The second phase included the practice phase. In this phase the robot moved towards the child and conducted the instructional trials with the protocol performed with the therapist.	The article suggested that the technological strength of this semi autonomous robotic intervention system that uses interaction technologies indicates that it can dramatically improve the treatment outcomes and social behavior in autistic children. The provision of immediate feedback with an improved algorithm for eye contact detection might be a key element in the effectiveness of the reinforcement system compared with previous studies involving robots that are remotely controlled by an operator. Moreover, the semiautonomous quality of the robot's reactions, which were based on object detection and classification technologies, is a promising technological aspect of the use of a robot as a co-therapist in the treatment of autism, and this deserves more study.	Social emotional aspects to robotic interventions with children have an underlying interest in the research field. This article addresses eye contact and facial emotional recognition that faces continual research in how robotic interventions play out in school or home programs. This article provides insight to social behavioral interventions that fit to a more neurodiverse framework by integrating emotional capture interventions that give insight to how autistic children react to robotic interventions. This would help contribute to a better understanding on how robotic interventions might suit individuals with specific social experiences with robots.

	a structured framework based on behaviorally validated strategies, such as the antecedent-behavior-consequence format, and using repetitive routines in the training elements to provide consistency that was independent of the emotional status of the subjects and individual differences in therapist expertise.				
van den Berk-Smeekens, I., de Korte, M. W. P., van Dongen-Boomsma, M., Oosterling, I. J., den Boer, J. C., Barakova, E. I., Lourens, T., Glennon, J. C., Staal, W. G., & Buitelaar, J. K. (2021). Pivotal response treatment with and without robot-assistance for children with autism: a randomized controlled trial. *European Child & Adolescent Psychiatry, 31*. 1871–1883. https://doi.org/10.1007/s00787-021-01804-8	The aim of this study is to provide more research on appropriate interventions for young children with autism. Since robotics are appealing to most children and may contribute to their motivation for social interaction, this study is conducted through a randomized control trial (RCT) comparing pivotal response time (PRT) and robot-assisted PRT with treatment as usual (TAU).	This study involved an exploratory three-armed RCT and was conducted within the context of clinical outpatient units of Karakter, a tertiary, multi-site center for complex child and adolescent psychiatry in the Netherlands. Seven different outpatient sites of Karakter were involved in this study, all using the same procedures and clinical protocols. An adaptive design was used to measure the effects of clinical outpatient treatment of autistic children in this naturalistic sample. Participants were randomly assigned to either PRT, robot-assisted PRT or TAU (1:1:1). Stratification was conducted based on age, total intelligence quotient (TIQ), and site, since treatment outcomes in young autistic children may vary by age and TIQ.	In the parent–child sessions, the therapist modeled the PRT techniques during therapist-child interaction, after which parents practiced the PRT techniques during parent–child interaction while being coached by the therapist.The main focus was on specific PRT techniques. Sessions were recorded on tape for further analysis. During the teacher sessions the teacher was involved in discussing and practicing the use of PRT techniques within the school setting. During the robot assistive PRT, a robot was added during the first 15 minutes of each parent-child session. During parent-home sessions, the children's process of target behaviors was taped and discussed as well as the parental use of PRT techniques at home. Target behaviors were observed and practiced during child-robotic interaction. The TAU group consisted of parents and their guidance intensive	With PRT total vs TAU values, there were no differences in change in general social communicative skills between the total PRT group and TAU. With PRT vs PRT + robot vs TAU values there was no significant difference found between the three groups in the change scores from baseline to endpoint on the SRS rated by parents. The higher gains in the robot-assisted PRT group on the parent-rated SRS and the blindly-rated ADOS-2 suggest that robot-assistance may contribute to treatment efficacy for children with ASD when combined with motivational components of PRT, such as incorporating child-preferred activities, stimulus variation, direct-response-reinforcement relationships, and reinforcement of attempts.	Findings suggest that there are gains in robot-assisted PRT groups which suggest future studies for child parent modifiers, the embedding of PRT social robotic interactions within the school setting, and integration of PRT with co-interventions and inclusion of long term follow-up measures. This specific study identifies an intervention contributing to a continued desire to find appropriate behavioral interventions for autistic children. The need for a continued understanding in providing a neurodiverse framework fits into this intervention provided by this article.

			family therapy, pharmacology, and a combination of these factors. Participants were recruited from clinical outpatient referrals to Karakter.		

Note: Summary of study characteristics sorted by reference, aim/purpose of study, methodology, intervention, outcomes, and critical findings related to the research question.