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The Role of Social Robots as Assistive Technologies in the Treatment of Autism Spectrum Disorder and Other Neurodevelopmental Disorders: Possible Interactive Play Scenarios

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Abstract

This chapter explores the utilization of social robots as assistive technologies in the treatment of children and adolescents with ASD and other neurodevelopmental disorders. It has been observed that these robots provide effective and engaging experiences for such individuals and both parents and children show a positive attitude towards this technology. In addition, parents perceive robots as more child-friendly than tablets or smartphones. That is why, the current section examines the potential of different Socially-Assistive Robots (SARs) in therapeutic sessions and presents various interactive play scenarios, designed by a team of specialists. Possible applications are explained and challenges, faced during the sessions, are pointed out. The paper also offers perspectives on the use of SARs which can create a nurturing and non-intrusive environment, leading to enhanced therapeutic results.

Keywords: Social Robots; Assistive Technologies; Autism Spectrum Disorder; Interactive Play Scenarios; Therapeutic Sessions.

The utilization of advanced technology in the treatment of Autism Spectrum Disorder (ASD) and other neurodevelopmental disorders has garnered increasing attention. Socially Assistive Robots (SARs) have become a focal point in the field of speech and language therapy. Although initial findings have shown promise, more investigation is required to comprehensively grasp the potential and practicality of SARs in ASD. Notably, these robots have been observed to offer effective and captivating therapy experiences for children and teenagers with diverse neurodevelopmental and communication disorders.

Robots possess the capability to repetitively reproduce specific words and actions, which can aid children in retaining and applying acquired vocabulary in their daily lives. In accordance with the systematic review conducted by Pivetti et al. (2020), the incorporation of educational robots in various types of interactions with children diagnosed with neurodevelopmental disorders has resulted in enhanced social engagement with peers and/or teachers/ other professionals. Children exhibit enthusiasm and active participation when a robot is involved in therapy sessions. As stated in Stankova et al. (2021), both parents and children show a positive attitude towards this technology. Furthermore, according to Lin et al. (2021), parents believe that robots are more child-friendly compared to other technologies like smartphones, tablets, and televisions. (This is attributed to the ability to predetermine and control the content of programs delivered through robots. Researchers face challenges when trying to develop an optimal design for child-robot interaction that effectively emulates natural human communication and can be applied in both in-person and online sessions. This endeavor necessitates the establishment of comprehensive evaluation criteria to assess the effectiveness and quality of the interaction, as well as the child's engagement, social behavior, and more. Various objective and subjective measurement methods, such as observation, behavioral analysis, gaze and speech detection, as well as questionnaires, are employed to gather data in this regard.)

The 2022 UNICEF (2022) report on assistive technologies for children with neurodevelopmental disorders highlights socially assistive robots as high-tech assistive technologies that show significant potential for enhancing social interaction and communication. SARs can function as friendly companions in games, facilitators in interactions with peers and adults, stimulate social engagement, and transform the child's role from a passive observer to an active participant. Among the wide array of interventions available, social robots have emerged as a promising tool to support the development of daily skills and enhance the overall quality of life (Scassellati et al., 2012; Valadão et al., 2016). Recent research indicates that robots are well-accepted by children and young individuals diagnosed with autism spectrum disorder, and their utilization is associated with positive effects on various aspects such as imitation abilities, eye contact, shared attention, behavioral responses, as well as repetitive and stereotyped behaviour (Pennisi et al., 2015; Van den Berk-Smeekens et al., 2020).

According to ICD-11 Neurodevelopmental Disorders, include Autism Spectrum Disorder (ASD), Disorders of Intellectual Development, Developmental Language Disorder, Developmental Learning Disorder, and others (WHO, 2019/2021). Scientists from the Institute of Robotics, Bulgarian Academy of Sciences, have developed a couple of game scenarios, specifically designed for children with different neurodevelopmental disorders. The aim of the current chapter is to present these scenarios, explain possible applications, point out challenges that were faced during sessions, and provide insights on the use of SARs in the treatment of ASD and other neurodevelopmental disorders in speech and language therapy.

The humanoid robot NAO is one of the socially assistive robots that have been used in play scenarios with children with ASD and other neurodevelopmental disorders. NAO is the most frequently used robot, which assists children with neurodevelopmental and communication disorders in individual sessions. It is equipped with many sensors and actuators that allow different modalities for interactions. It can perform gestures, play sounds, and recognize objects, words, landmarks, and barcodes. NAO has a preinstalled operating system, NAOqi. The programming of the robot is performed in two ways: by using the graphical interface of the Choregraphe environment and/or in Python programming language inside Choregraphe or from an external IDE.

EmoSan is the other robot involved in the therapy sessions. A group of scientists from the Institute of Robotics have developed it. The robot has six degrees of freedom and two platforms – a base and a moving platform. EmoSan incorporates head movements. The robot design is built upon the Gough-Stewart platform. This innovative utilization of the Gough-Stewart platform allows for a compact and easily manageable emotion-expressive robot (Pancho Dachkinov et al., 2018).

One of the scenarios, designed by speech and language therapists and the engineers from the Institute, is about farm animals and their voices and names. This scenario can be performed in remote speech and language therapy, and its objective is to enrich a child's vocabulary. The treatment domain is the language one, and the scenario is appropriate for children with ASD and other neurodevelopmental disorders. The techniques that have been used are identification of farm animal voices, as well as identification and pronunciation of words related to a farm. This is a cognitive play, and the child who participated in the experiment was four years old. There are five participants in this scenario - a speech and language therapist (who controls the game), a social robot NAO (in the role of an instructor), a social robot EmoSan (which is a playmate), a parent (who is a co-therapist) and a child with ASD or other neurodevelopmental disorders (who is a playmate). During the experiment, the social robot NAO gives instructions to the child to identify and pronounce words, based on pictures of farm animals and the social robot EmoSan interacts with the child as a playmate throughout the game. The platform BigBlueButton is used for telepresence.
Another play scenario with the two robots is called "Storytime". The objective is for the child to follow a story and to represent a story as a sequence of scenes in time. This scenario is again appropriate for children with ASD and other neurodevelopmental disorders. The experiment has been conducted with 15 children between the ages of 3 and 10 years. Three pictures of story scenes and a whisk have been used in the game.
The other game, which the scientists created, is about colors. Its objective is to improve the receptive vocabulary of children. Children have to identify the vocabulary of a closed set of words. This is a cooperative and practiced play. Two pictures are placed in front of a child. NAO says, "Give me X". The child chooses the picture of the color he/she has heard and puts it in the robot's hand. The four participants in this scenario are the same: a speech and language therapist, a social robot NAO, a social robot named EmoSan and a child with neurodevelopmental disorders. The children, involved in the game, were in the age group of 3-10 years.
Another game, called "Shopping Game", represents environmental sounds and vocabulary used in everyday routine. The vocabulary is related to running water in the bathroom when taking a shower and the sound from teeth brushing. NAO can play the sound of a shower and, at the same time, show the relevant body movements, e.g., "brushing" the teeth. First, the

child chooses products for taking a shower – soap, shampoo, and bath sponge and shows them to NAO in order to check if they are the correct ones. After that, NAO plays the sound for teeth brushing, and the child selects the appropriate products (Andreeva & Ioannou, 2020; Polycarpou et al., 2016). In this game, a cash desk toy has been used. The child pretends that they help NAO check the products on the cash desk. The child decides whether to pay with a plastic card or cash. The children were in the age group 3-10 years.

The children, who were involved in the therapy sessions, have ASD, Developmental Language Disorder and/ or Developmental Learning disorder. The scenarios in all plays described, have been carried out in a clinical setting over multiple sessions. The activities can also include more participants to promote a cooperative play. The results indicated that nearly all children readily participated in the play-like activities and displayed a keen interest in interacting with the robots. The reported results show that the SARs have increased motivation and enhanced children's attention. One of the challenges during the sessions was that the children, especially those with ASD, had difficulties initiating, maintaining joint attention, and interacting with their interlocutor (Andreeva et al., 2022). After employing NAO in speech therapy, the project team found out that there was a necessity to broaden the communication environment between children and robots, so this is a perspective for future work with NAO (Georgieva-Tsaneva et al., 2023).

Unfortunately, the number of children involved in the interactions with the robots was insufficient, and further investigation is required to broaden and enhance our understanding of this subject. However, the implementation of SARs into speech and language therapy for children with ASD and other developmental disorders can establish a supportive and unobtrusive environment for children, resulting in improved therapeutic outcomes. Based on a comprehensive review, done by the scientists from the Institute of Robotics and other academic organisations, it has been found that there is an increasing number of studies that have documented encouraging outcomes in the implementation of SARs in the context of speech and language therapy (Georgieva-Tsaneva et al., 2023). Both the kids and the parents have enjoyed playing games and doing activities with the robots, which has motivated them to continue the sessions with SARs' help. We hope that incorporating SARs into speech and language therapy will enhance the language development of children with neurodevelopmental disorders and have a positive impact on their overall growth and quality of life.

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