THE ROLE OF SOCIAL ROBOTICS AS ASSISTIVE TECHNOLOGIES IN THERAPY FOR NEURODEVELOPMENTAL DISORDERS: POSSIBLE INTERACTIVE PLAY SCENARIOS

Mayiana Mitevska
"Paisii Hilendarski" University of Plovdiv, Bulgaria
majana.mitevska@uni-plovdiv.bg

Denis Nikiforov
"Paisii Hilendarski" University of Plovdiv, Bulgaria
denisnikiforovblog@gmail.com

Paulina Tsvetkova
Institute of Robotics at the Bulgarian Academy of Sciences, Bulgaria
p.tsvetkova@ir.bas.bg

Abstract

The current article delves into the use of social robots as assistive tools in the therapy of children and adolescents with different neurodevelopmental conditions. Research indicates that these robots offer engaging and effective therapeutic experiences, with both children and their parents responding positively to the technology. Parents, in particular, tend to view robots as more suitable for children than devices like tablets or smartphones. Accordingly, this work investigates the therapeutic potential of various Socially-Assistive Robots (SARs), showcasing interactive play scenarios developed by expert teams. It outlines potential applications and highlights challenges encountered during therapy sessions. In addition, the article discusses how SARs can foster a supportive, non-intrusive setting that may contribute to improved therapeutic outcomes.

Keywords: *Social Robotics; Assistive Technologies; Neurodevelopmental Disorders; Therapy; Interactive Play Scenarios.*

INTRODUCTION

The use of advanced technologies in the treatment of Autism Spectrum Disorder (ASD) and other neurodevelopmental disorders is attracting increasing attention. Socially Assistive Robots (SARs) are becoming a focal point in the field of speech and language therapy. Although initial results are promising, more in-depth research is needed to fully understand the potential and practical applicability of SARs in neurodevelopmental disorders. Notably, these robots have been found to offer effective and engaging therapeutic experiences for children and adolescents with various neurodevelopmental and communication disorders.

Robots have the ability to repeat specific words and actions, which can help children retain and apply newly acquired vocabulary in everyday life. According to the systematic review conducted by Pivetti and colleagues [1], incorporating educational robots into different types of interactions with children diagnosed with neurodevelopmental disorders leads to increased social engagement with peers and/or teachers/other professionals. Children show enthusiasm and active participation when a robot is involved in therapeutic sessions. As reported by Stankova et al. [2], both parents and children exhibit positive attitudes toward this technology. Moreover, Lin et al. [3] note that parents consider robots more suitable for children than other technologies such as smartphones, tablets, and televisions. This is due to the possibility of predefining and controlling the content delivered through robots.

Researchers face challenges in trying to develop an optimal child–robot interaction design that effectively resembles natural human communication and can be applied both in face-to-face and online sessions. This endeavor requires the development of comprehensive evaluation criteria to measure the effectiveness and quality of the interaction, as well as the child's engagement, social behavior, and other aspects. Various objective and subjective measurement methods are used to collect data in this regard, such as observation, behavioral analysis, eye tracking and speech detection, as well as questionnaires.

UNICEF's report [4] on assistive technologies for children with neurodevelopmental disorders highlights social assistive robots as high-tech aids with great potential to improve social interaction and communication. Social robots can act as friendly companions in games, mediators in interaction with peers and adults, stimulate social engagement, and transform the child's role from a passive observer into an active participant. Among many available interventions, social robots stand out as a promising tool for supporting the development of daily skills and increasing overall quality of life [5], [6]. Recent research shows that robots are well accepted by children and young people diagnosed with ASD, and their use is associated with positive effects on various aspects such as imitation skills, eye contact, joint attention, behavioral responses, and on repetitive and stereotyped behaviors [7], [8].

According to ICD-11, neurodevelopmental disorders include autism spectrum disorder (ASD), disorders of intellectual development, developmental language disorders, learning disorders, and others [9]. Scientists from the Institute of Robotics at the Bulgarian Academy of Sciences have developed several play scenarios specifically designed for children with different neurodevelopmental disorders. The purpose of this article is to present these scenarios, explain possible applications, point out challenges encountered during sessions, and provide information about the use of SARs in the treatment of ASD and other neurodevelopmental disorders in speech and language therapy.

INTERACTIVE PLAY SCENARIOS WITH SOCIAL ROBOTS

The humanoid robot NAO (https://us.softbankrobotics.com/nao) is one of the social assistive robots used in play scenarios with children with ASD and other neurodevelopmental disorders. NAO is the most commonly used robot to support children with neurodevelopmental and communication difficulties in individual sessions. It is equipped with multiple sensors and actuators that enable different modes of interaction. It can perform gestures, play sounds, and recognize objects, words, landmarks, and barcodes. NAO has a preinstalled operating system—NAOqi. The robot can be programmed in two ways: via the graphical interface of the Choregraphe environment and/or using the Python programming language within Choregraphe or via an external integrated development environment (IDE).

EmoSan is the other robot included in the therapeutic sessions. It was developed by a team of scientists from the Institute of Robotics. The robot has six degrees of freedom and two platforms—a base and a movable platform. EmoSan includes head movements. The robot's design is built on the Gough–Stewart platform. This innovative use of the Gough–Stewart platform enables a compact and easy-to-control robot capable of expressing emotions [10].

One of the scenarios created by speech therapists and engineers from the Institute is related to farm animals—their sounds and names. This scenario can be used in remote speech therapy; its goal is to enrich the child's vocabulary. The domain of impact is language, and the

scenario is suitable for children with ASD and other neurodevelopmental disorders. The techniques used include recognition of animal sounds as well as recognition and pronunciation of words related to the farm. This is a cognitive game, and the child involved in the experiment was four years old. Five participants are involved: a speech therapist (who controls the game), the social robot NAO (as instructor), the social robot EmoSan (as player), a parent (acting as co-therapist), and a child with ASD or another neurodevelopmental disorder (as player). During the experiment, NAO gives instructions to the child to recognize and pronounce words based on images of farm animals, while EmoSan interacts with the child as a partner throughout the game. The BigBlueButton platform is used for telepresence.

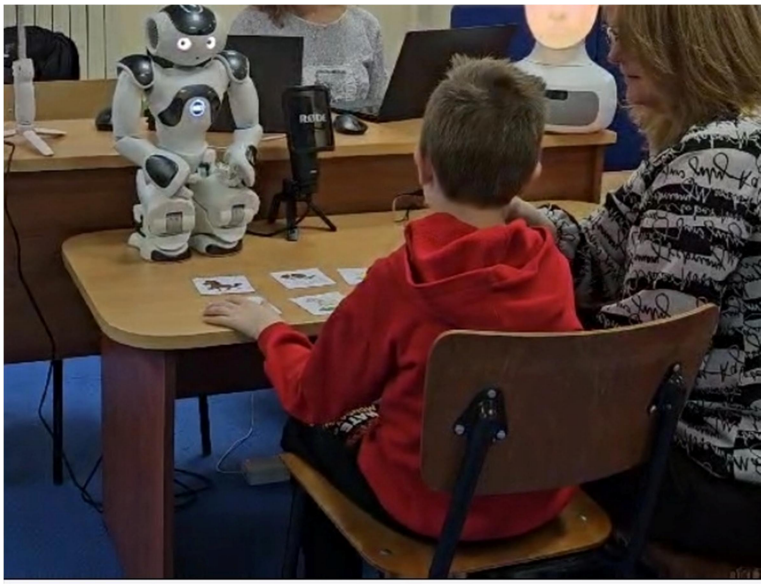

Fig. 1 Therapeutic session of a child with a neurodevelopmental disorder using the humanoid robot NAO. Source: authors' contribution

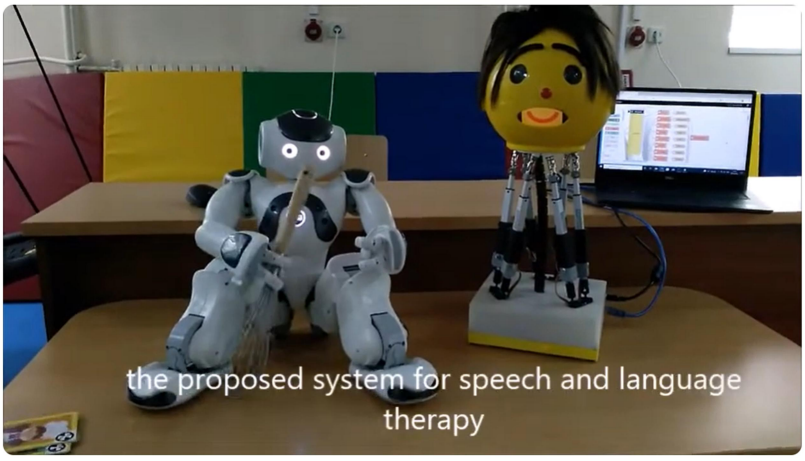

Fig. 2 Scene from a video during a therapeutic session with children with neurodevelopmental disorders, using the humanoid robot NAO and the emotion-expressive robot EmoSan

Another play scenario with both robots is called "Story Time". The goal is for the child to follow a story and present it as a sequence of scenes over time. This scenario is also suitable for children with ASD and other neurodevelopmental disorders. The experiment was

conducted with 15 children aged between 3 and 10 years. Three pictures with episodes from the story and one mixing stick were used in the game.

Another game developed by the scientists is related to colors. Its goal is to improve children's receptive vocabulary. Children must recognize words from a closed set. This is a cooperative and practice-oriented game. Two pictures are placed in front of the child. NAO says: "Give me X." The child chooses the picture with the color they heard and places it in the robot's hand. The four participants in this scenario are: speech therapist, social robot NAO, the social robot EmoSan, and a child with a neurodevelopmental disorder. The children participating are aged between 3 and 10 years.

The game called "Shopping" presents environmental sounds and vocabulary used in everyday life. The vocabulary is related to running water in the bathroom during a shower and the sound of brushing teeth. NAO can play the sound of a shower while demonstrating corresponding body movements, such as "brushing" teeth.

First, the child selects products for taking a shower—soap, shampoo, and a bath sponge—and shows them to NAO to check whether they are correct. Then NAO plays the sound of brushing teeth and the child selects the appropriate products [11], [12]. A toy cash register is also used. The child plays the role of an assistant who helps NAO check the products at the checkout. The child decides whether to "pay" with a plastic card or in cash. The children who participated were between 3 and 10 years old.

The children who participated in the therapy sessions were diagnosed with ASD, developmental language disorder and/or learning disorder. The scenarios in all described games were implemented in a clinical environment across multiple sessions. The activities can involve additional participants in order to encourage cooperative play.

The results show that almost all children readily participated in the play activities and demonstrated strong interest in interacting with the robots. The reported results indicate that SARs increase motivation and improve children's attention.

One challenge during the sessions is that children—especially those with ASD—experience difficulties initiating, maintaining joint attention, and interacting with their conversation partner [13]. After using NAO in speech therapy, the project team found that there is a need to expand the communication environment between children and robots, which is a direction for future work with NAO [14]. Both children and parents enjoy playing games and performing activities with the robots, which motivates them to continue sessions supported by SARs. We hope that incorporating SARs into speech therapy will support the language development of children with neurodevelopmental disorders and will have a positive impact on their overall development and quality of life.

CONCLUSION

The presented play scenarios involving SARs such as NAO and EmoSan demonstrate significant potential to support speech and language therapy for children with ASD and other neurodevelopmental difficulties. The games not only encourage language and cognitive development, but also stimulate social interaction, attention, and motivation. The involvement of parents, speech therapists, and robots creates a supportive and engaging therapeutic environment in which children feel confident and interested.

The results of the sessions show that robots are perceived positively by both children and their parents, which opens prospects for broader application in therapeutic practice. Alongside the positive effects, challenges remain related to improving communication capabilities and maintaining joint attention in children with ASD. In this regard, future efforts should focus on refining the design of human–robot interaction and adapting content to the individual needs of each child. Integrating SARs into speech and language therapy not only modernizes the process, but also contributes to better quality of life and fuller development for children with various neurodevelopmental disorders.

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