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Robotics for Autistic Children

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Abstract

A range of chronic difficulties known as autism spectrum disorders interfere with social interactions and communication. The state of the art shows how robots in particular can provide potential methods to advance ASD research and treatment. This review aims to investigate how robot-assisted therapy techniques support children with autism in increasing social contact and in imitating, recognizing, and expressing their feelings. If robots appear to be useful tools for assistive therapies was one of the paper's main questions. The study team behind this publication came to the conclusion that robots are extremely effective in the intervention process and provide ASD youngsters with a predictable and secure setting. In addition to the aforementioned, this project also discusses ethical concerns that therapists and researchers should keep in mind while human-robot interaction is taking place.

Keywords: Robots; Autism; Intervention; Digital technologies; Social-emotional abilities.

1. Introduction

Autism is a condition that encompasses a wide range of impairments, the severity of which varies from person to person, and which damage social relationships, communication, and imagination. Since it interferes with a person's development at every stage, autism is a pervasive developmental condition. The word "disorder" implies a sense of departure from normal, while the adjective "pervasive" suggests that the condition has an overall impact on the person's development. There is currently no known cure for autism, but with early intervention, much can be done to enhance the quality of life for people who are affected. Throughout the course of treatment, many therapeutic strategies are in this situation. However, due to the nature of the disorder and its large variety of symptoms, there cannot be a single approach established as the best treatment model, because it can work well with a child but may not work at all with another [1,2]. The use of robots in autism intervention has been widely used in the last years. Over the last decade, robots are used as intervention tools for individuals with Autism Spectrum Disorder (ASD). There are numerous robots that mimic human movements, body language, and facial expressions. These robots come in a variety of shapes and sizes. Numerous fields of autism research have made use of robots as supporting technologies. In particular, they have been utilized to support children's social interaction and to teach them complicated social behaviors like respecting others' personal space, adaptation, controlled speech, and emotion awareness. The ability of robots to observe and affect autistic children's behavior, as well as to assist the therapist, is generally unreliable. However, it is important to note that they are highly expensive and that a technician must be present to ensure proper use [3, 4].

We provide studies on robot therapy for autistic youngsters in this publication. As social contact is a key component of autism, we start by introducing robots that help autistic youngsters develop their social abilities. Then, using mimicry and other games, we discuss robots that promote emotional expression in children with autism. We conclude by talking about the moral dilemma surrounding the use of therapeutic robots in autism treatment. This paper's major goal is to look into how robots affect social and emotional interaction therapy for autistic people, both favorably and unfavorably.

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2. Enhancing Social Skills

Robots have been employed as intervention tools for people with Autism Spectrum Disorder (ASD) for the past ten years, claim Sartorato F., Przybylowski L., and Sarko D. K. [4]. There are numerous robots with various features and appearances that mimic human movements, body language, and facial expressions. The robot "ROBOTA" was made available as part of the AuRoRa project, and it assisted children with ASD in growing their social skills, joint attention, and ability to mimic the movements of the robot. Additionally, KASPAR, another humanoid robot, assisted youngsters with ASD in learning how to work with adults by boosting their social conduct. In 2005, M. Blow created the first humanoid robot, KASPAR, as a Human Robot Interaction (HRI). Since then, the robotic platform has continuous development due to the needs of the users and the technological advancements [5]. Further information about KASPAR is reported at the end of this section. Additionally, robots with a cartoonish appearance, whose name, are Tito and Keepon, respectively were attractive to children with ASD and helped them imitate facial expressions and increase their joint attention. Additionally, animals-themed robots that were utilized as intervention tools for kids with ASD helped them learn new social skills and emulate good behavior. Examples of these robots are PABI, which can mimic human emotions, and Probo, which can teach children with ASD appropriate social conduct by telling them tales about social situations. According to research, robot-assisted treatment helped children with ASD adapt the abilities they learned during the intervention to interactions with other kids and adults in the real world. Additionally, this type of therapy enhanced interaction levels and helped children with ASD further develop their social abilities [4].

Prior to approximately 10 years, Stanton et al. suggested a close relationship between kids and robots. They looked into how four autistic youngsters interacted with Robota, a humanoid robot, at first. The total level of interaction with the robot increased for two out of the four kids across all sessions. They next observed 11 autistic children utilizing an autonomous dog-like robot (AIBO) in comparison to Kasha, a mechanical dog, and came to the conclusion that the children in the AIBO room interacted with AIBO more frequently than they did with KASHA. Additionally, with AIBO, they said more words per minute. When they got AIBO, they dealt with real interactions with the experimenter more frequently. In the interaction with AIBO, social interaction was increased, a behavior associated with children of a typical development. From the indicative results it was found that robots can help children with autism in social interaction [6]. Six years later, another pilot research by Barakova et al. referred to LEGO therapy based on human-robot interaction with children within the spectrum of autism. The humanoid robot replaces one of the children in the game scenario that follows the design of LEGO therapy. Children's interest is maintained throughout training by adopting extended training scenarios. An entire LEGO creation was the goal of a pilot and final experiment that involved designing, carrying out, and analyzing a robot's intervention in the LEGO play between kid fairs. Barakova et al. discovered two things: A play-based robot scenario that allows for ongoing play during sessions opened up options for long-range interventions using robots and resulted in a semantic increase in social initiations during the intervention in natural settings; b) incorporating dyadic interactions between a robot and a child within triadic games with robots has positive effects on the child's engagement and on creating learning opportunities that conform to the chosen therapeutic approach [7].

The Queball robot, which has a straightforward global morphology along with a selection of autonomous behaviors, was unveiled by Salter et al. in the same year. The platform is easy to use, safe, and offers a variety of interactive kinetic, virtual, acoustic, and tactile aspects that are designed to improve the child's learning and playing skills. Additionally, it offers WiFi connectivity to a computer or other devices. The outcomes demonstrated that this device does not require any specific technical assistance to be used in classrooms. Because the autistic child appeared at ease and amused, the interaction between the child and the robot was described as calm and intriguing. Finally, it was observed that children with autism developed the ability to play with other people without facing any conflicts [8]. Additionally, Tennyson et al. coined the term "Socially Assistive Robotics" (SAR) to refer to the fourth generation of robot agents that use Lego NXT public platforms. In order to promote an alternative educational strategy for teaching social behavior, the aforementioned platform is paired with pedagogical principles and social scenarios. Robotic social assistants (SARs) encourage autonomous social behavior by allowing kids to connect with a three-dimensional object through touch, verbal communication, physical play, and learning through imitation and interaction. When contrasted to the outcomes of human interaction, the results suggested that SARs had helped individuals exhibit less stereotypical behavior [9]. Srinivasan et al. conducted a trial in which three groups of ASD children were randomly assigned to receive the proper treatments. The robot group participated in activities designed to teach them how to mimic robot games, the rhythm group engaged in activities including movement and music, and the comparison group concentrated on standard tablet screen activities. According to the study's findings, the robot group performed better when it expressed itself. Despite not having enough time to converse with the robot, the individuals in the robot group improved their language and social verbalization abilities throughout the sessions. However, the ASD kids in the robot group were unable to generalize their new abilities ina real social interaction with a human. Due to the restricted motor movement, the limited and difficult wordiness and the partial autonomy of the robots, there were many disadvantages in robot-assisted long-term interventions for children with ASD [10]. The research by Esteban et al., which presents Robot-Assisted Therapy

(RAT), is another study that supports the use of robots in autism intervention. There were two phases of the survey. Wizard of Oz (WoZ) was a robot utilized in the first phase, and RET robots were employed in the second phase with a semiautomatic system. Following the completion of the two phases, they were evaluated against Standard Human Treatment (SHT). The findings indicated that certain individuals performed better while interacting with robots, and it was determined that RAT had been successfully utilized to hone social skills in kids with ASD [11].

The NAO robot was reportedly utilized as an intervention technique in a study by Desideri et al. with a sample of three preschool children who had been diagnosed with ASD. The intervention consisted of two components (control and robot intervention), in which kids took part in activities using toys and objects from their daily lives with a variety of goals in mind, including imitation, positive reinforcement, and communication or language understanding. The activities were structured the same in both sections; the only difference was that in the first session, the kids interacted with the teacher, and in the second, they did so with the robot. The robot, which maintained children's attention and assisted them in achieving the goals of the activities, was shown to be an essential component of the intervention. The most significant finding was that the kids engaged in the robot interaction more than they did with the teacher [12]. Additionally, Hina et al. concentrated on the interaction of autistic people with NAO, which varies from the rest in its methodology because it employs a multimodal fusion of information and has the capacity to read a complex order and divide it into basic work on interactional fundamentals. Thus, the NAO robot facilitates social contact for kids with ASD [13]. Furthermore, Taheria, Meghdaria, Alemia and Pouretemad developed an innovative robotic music therapy intervention, originally designed to teach the basic principles of how to play the drums and the xylophone to children with autism, using the NAO robot as an assistant and then help them develop their social and cognitive skills as well as their kinetic imagination. The study's objective was to assess the effects of the program's three related groups' interventions. The robot, the parent, or the therapist would initially play music using actual xylophones or drums while the child would have to do the same. With the baguettes in its hands, the NAO robot was trained to play the musical instruments. The survey's findings demonstrated that the study's participants' social and cognitive abilities were positively impacted. For kids who fell into different degrees of the spectrum, music therapy did not appear to have the same benefits on participants' conduct in general [14].

In a recent study, Scassellati et al. presented an intervention in which 12 ASD-diagnosed children participated and attended special education courses. Over the course of a month, the subjects interacted for 30 minutes each day with their caregiver and a social autonomous robot. Each session began with a story about a day in the life of a child narrated by the robot, after which the kids engaged in games under its direction. The intervention's goal was to generalize the participants' various social skills while interacting with adults. The findings of this study demonstrated that the robot assisted kids in growing their social and communication abilities. Moreover, the participants paid more attention when there was a robot than when they played a game themselves. The most important result was that the children were able to adapt these social skills in real interactions with adults [15]. Melo et al. presented the INSIDE system, a network-based robot system designed to allow the use of mobile robots as active players in the treatment of children with autitic disorders. The system was made up of ASTRO, an autonomous mobile robot that could interact with people while a child moved around the room performing various tasks during a health care session. The robot was essential to the healing process because it invited the youngster to participate in the different activities, described them to the child, and offered encouragement. Using an autonomous robot with driving and multitasking capabilities, operating as a social agent and engaging in rich social interaction with completely autonomous children, this study was a pioneer in its field. While using completely autonomous robots for ASD therapy, the INSIDE system differs from existing systems in that it enables sophisticated, semi-structured interaction [16].

Furthermore, helping people find jobs is another significant way that robots can help with autism. A work environment simulation tutorial was created by Kumazaki et al. utilizing an Android robot, and it examined changes in self-confidence as a result of learning nonverbal communication techniques and stress management. Participants' self-reports on their level of confidence and salivary cortisol levels were used to gauge these changes. The findings of the aforementioned measurements indicated that "yes" was the response to the question of whether or not they wanted to re-interview the participants using the robot. Additionally, none of the members of the robot team displayed any discomfort or technological concerns throughout the test. Still, the results showed that in the non-verbal communication category there was a significant improvement for the robot team [17]. Finally, a lengthy investigation on KASPAR revealed that it can be applied to encourage and facilitate cooperative play among autistic kids. Six autistic children participated in structured play sessions with and without the robot, using a specially created cooperative game that was centered on mimicry. After playing in pairs with the robot KASPAR, the study showed how several pairs of autistic youngsters displayed improved social behaviors when playing with one another [18]. Additionally, a recent study by Wood et al. demonstrated that KASPAR can aid autistic children in growing their visual perspective skills—the capacity to view the world from the perspective of another person [19].

Alhaddad et al. provided an alternative perspective on social robot interactions and investigated the harm brought on by interactions between social robots and autistic children, particularly when those youngsters engage in provocative behaviors like throwing things, kicking, or beating themselves up. These actions have the potential to hurt both the children and anyone nearby. So, using severity indicators for one of the provoking acts, namely object tossing, they calculated the size of this injury. The findings demonstrated that total injury levels based on particular severity markers are low in comparison to the corresponding limitations [20].

3. Development of Emotional Skills

Robots have not only aided in the social empowerment of autistic children receiving therapy, but they have also improved their emotional skills, which are considered to be challenging. Children with ASD tend to feel at ease with non-humanoid robots, according to Adams and Robinson. However, a robot with genuine human features aids in the development of facial recognition skills in ASD kids. The FACE project (Facial Automation for Conveying Emotions), which employs a lifelike android head and whose primary goal is to improve children's social and emotional skills, is mentioned by the researchers. The android head is able to illustrate six basic emotions and can be controlled by the therapist and the child. During the intervention, the behavior of the participants, their interaction with the android head and the imitation of the facial expressions were observed. The results showed that there can be an increase in the recognition of realistic emotions [21]. Additionally, Pop et al. looked at whether the social robot Probo could assist kids with autism in recognizing situation-based emotions. The outcomes of their work demonstrated that the participants' performance increased. Particularly, children performed better when detecting both grief and happiness, with moderate to high effect sizes. Therefore, this study established that robot-assisted therapy can enhance autistic children's emotional as well as social skills [22]. Moreover, Leo et al. study was to become the first attempt to use machine learning strategies during ASD child-robot interactions in terms of mimicking facial expressions, making it possible to objectively assess children's behavior and then introduce a measure of treatment effectiveness. In particular, the program focused on basic emotional recognition skills. In addition to the aforementioned, applicable innovations can also contribute to this endeavor by offering a Facial Expression Recognition (FER) mechanism that can automatically identify and monitor a child's face before recognizing emotions using machine learning. There were two distinct experimental sessions; the first looked at the FER using datasets that could provide the suggested action and identify the current level of recognition strategy precision. The second involved children with ASD, and it was an exploratory study exploring who would benefit from the inclusion of the FER engine in the therapy protocol that was successfully utilized to track kids' behavior [23].

Zeno Robot, a humanoid robot, was used in a study by Salvador, Silver, and Mahoor. The study's objective was to compare youngsters with and without ASD in terms of their ability to recognize emotions. First, the robot interacted with the kids before Zeno used a game to teach them about the six fundamental emotions: happiness, surprise, sadness, anger, contempt, and fear. Each emotion was guessed by the participants, and the robot determined whether or not the answer was correct. The kids may communicate with the robot after the game. The findings demonstrated that both groups were equally capable at identifying emotions. Children with autism found it difficult to distinguish Fear or Disgust, but both groups made better scores when the emotions were presented through gestures [24]. The following year, in Boccanfuso et al. study, an emotion-simulating robot was used in order for child-robot interactions and affective responses to this robot to be analyzed. In this method, the relationship between play and affective response and the degree of autism as measured by the Autism Diagnostic Observation Schedule (ADOS) was evaluated [25], in addition to variations between the reactions of generally developing children and children with autism being examined. Costa et al.'s study uses a QT robot with a screen on its face where emotions are visually represented with the help of animated characters in order to educate children with autism about how to better express their feelings. There are many levels of complexity and a straightforward method for expressing emotions. Throughout the procedure, emotional and social issues are presented using paradigms so that the kids may understand them [26].

Using the NAO robot, So et al.'s study sought to teach Chinese children with ASD how to recognize and make pantomime gestures that could aid in their ability to express their feelings. The intervention was divided into two stages: producing gestures and recognizing gestures. Two groups of study participants were created: the control group and the intervention group. The findings of this study demonstrated that the youngsters were instructed to identify and make motions when interacting with the NAO robot. However, when communicating with a real person, the participants struggled to make gestures accurately and were unable to generalize the significance of gestures [27]. Chevalier et al. designed a personalized robot environment for social learning for people with autism. They assessed the possible relationship between recognition ex- pressions of the body/face and emotions as well as proprietary and visual concepts of integrating an atom. They began by outlining the layout of EMBODIEMO, a database platform that contains video of body and face emotions. Then, they looked at how those with normal development (TD) and those with autism spectrum disorder (ASD) differed in their visual profiles of emotion perception. The findings demonstrated that individuals who placed a higher priority on visual cues had the highest recognition scores. However, they discovered that those TDs who concentrated on eloquence had superior recognition outcomes. Participants with ASD in particular received worse emotion recognition scores. The findings indicate that the combination of visual and perceptual cues in autism treatments is crucial because it can have an impact on how well children with ASD are able to recognize emotions [28].

A novel robot-based intervention paradigm was introduced by Javed et al. to address the aesthetic challenges of emotional treatment and cure in autistic youngsters. Expandable robotic interactions with socio-emotional emotions based on gestures and characters are provided using three different sorts of systems. An emotional interaction game in mobile computing environments, an interactive robot encounter with social scenarios, and gesture recognition games that gauge verbal and emotional processing at a socio-emotional level are all included in the intervention's structure. They established two teams. The research revealed that while children with ASD engaged in the emotion control game less frequently and paid less attention to appearance, they exhibited more typical instances of self-diagnosed interactions and imitation robot behaviors. While their overall performance in the gesture recognition game was lower than the control group, it should be noted that the best individual performance came from an ASD child [29]. Another recent study by Marino et al. examined a robot that was semi-autonomous. 14 kids participated in this study and were randomly assigned to one of two groups (the control group or the experimental group). It was possible for a semi-autonomous robot to provide assistance, make an effort to communicate and express feelings, and gather data regarding participant behavior using a camera. The results revealed that both the control and experimental groups performed worse than would have been predicted given their ages before the intervention. It is significant to note that both teams' performance increased as a result of the intervention, but the children who interacted with the robot had a stronger knowledge of emotions. Additionally, autistic people had a greater capacity for comprehending the opinions, feelings, and thoughts of others. [30].

Finally, we must highlight the productive and effective role of digital technologies in the field of emotional education. These technologies, which include mobile devices (35–38), a variety of ICTs (39-58), AI & STEM ROBOTICS (59-63), and games (64-66), facilitate and improve educational procedures such as assessment, intervention, and instruction. In addition, the use of ICTs in conjunction with theories and models of metacognition, mindfulness, meditation, and emotional intelligence cultivation [67-93], accelerates and enhances educational practices and outcomes, particularly for autistic children.

4. Moral Concerns

When using humanoid robots in autism-related robot-assisted therapy (RAT), there are many ethical considerations that should be made, such as the degree of emotional attachment, the use of robots as human substitutes in therapy, and the requirement for briefing the target group on the accepted ethical principles and protocols. More particular, autistic youngsters may think of the robot as an independent, autonomous person capable of cognitive interaction and attachment. The method that ensures the child sees the robot clearly as a friendly educational toy rather than a replacement for a human buddy may be the answer to the issue. As far as the use of the robot as a human is concerned, results showed that the majority of the participants agree to include robots in the therapy because it is ethically acceptable and only 26 per cent believe that robots can replace humans in the therapy. Lastly, the participants should give their consent before joining the experiment and be briefed on the ethical protocol and guidelines [31]. Moreover, Mark Coeckelbergh et al. have conducted a survey of questions about what people think of using robots in ASD therapy. The results are the most important for some of the basic ethical and therapeutic issues identified when it comes to robots. The analysis is founded on the responses to two questions: "Is it morally acceptable to use social robots in the treatment of autistic children?" and "Is the use of social robots in healthcare ethically acceptable?" The vast majority of respondents supported the use of robots in the healthcare system, including the treatment of children with ASD with robot assistance. However, a sizable percentage of participants (44%) opposed the idea of replacing therapists with robots, according to the researchers' discussion of ethical considerations. Instead, many respondents preferred that the therapist supervise the encounter and that the robot operate remotely rather than totally automatically [32].

The Haring et al. essay includes instances of robotics' detrimental effects on ethical considerations. Submissions are anticipated to be well established in the literature on humanoid robot intervention (HRI), technology ethics, and a wide range of perspectives (including analytical, empirical, technical, or planning-oriented). Examples include inverted robots (e.g., malicious robots, robots that give information to unintended sources), deceptive robot presentations (e.g., people's tendency to give robots sensitive information, a tendency for people to work with automation), dark applications (e.g., psychological manipulation of people by robots, responses to the application of robot rules), and unintended social robot effects (e.g. a disadvantage of explanatory robots, unintentional robot operations as a threat, socially interactive consequences of a robot, impact of robots on interpersonal relationships), solutions (e.g., enforcement of good practices, giving to the man tools to defeat the dark side, public education strategies for informing users about real concerns when it comes to social robots) [33]. Legal initiatives, such as the ISO 13482:2014 Personal Care Robots, the BS 8611:2016 Guide, and IEEE Ethically Aligned Design 2017 from the IEEE Global Initiative and Standard Association, which refer to the favorable and unfavorable effects of robot technology, also address the ethical design of robotic systems and application with robots. Additionally, there are specific rules pertaining to various diseases like autism as well as international policies on drones, autonomous automobiles, and other technologies. However, these endeavors provide those who work with robots with ambiguous instructions [34].

According to Villaronga & Albo-Canals, a social robot is both a technological product and a social being. This combination makes it difficult to understand what legal requirement must be followed when the researchers design a social robot intervention. The only ethical issue about the design of robots is ISO13482:2014, which specify robots' characteristics such as the robot shape, the robot movements, energy supply and storage and autonomous decisions of the robot. Moreover, social robots interact with special needs children and develop a relationship with them. In the EU the General Data Protection Regulation is legislated in May 2018 and the personal information of the users in therapies with robots must be protected. Hence, the design of social robots should follow and obey the rules, so as not to put at risk the therapy of people with special needs, such as children with ASD [34].

5. Conclusion

Finally, it is evident that robot-based therapies can aid in the treatment of autistic children. All of the robots discussed in this paper have been created to play many different roles through interesting activities in order to educate autistic youngsters in the social and emotional domain. During the aforementioned investigations, imitation, shared attention, emotion and facial recognition, triadic interaction, and tactile social behavior were all examined. In conclusion, the social skills and emotional development seen in children with ASD while engaging with robots enables us to accept the critical role that robots play in autism therapy. The emotional attachment that children have to robots and the proportion of uses during the entire therapeutic process are two ethical concerns that should be taken into account. Overall, we firmly believe that despite their helpful function in autism therapy, humans should not be replaced by robots; rather, robotics technology should be a supportive tool used by humans.

Compliance with ethical standards

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Disclosure of conflict of interest

The Authors proclaim no conflict of interest.

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