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AUTISM SPECTRUM DISORDERS AND AI: APPLICATIONS AND AREAS OF PROMISE

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Abstract

Autism spectrum disorder (ASD) is a complex neurodevelopmental condition characterized by challenges in social communication and repetitive behaviors. The spectrum is broad, with individuals exhibiting a wide range of strengths and difficulties that affect their daily functioning and learning. The World Health Organization estimates 1 in 100 children globally having been diagnosed with ASD, whereas the United States Center for Disease Control and Prevention reports 1 in 36 children with ASD diagnosis in the U.S.A. Artificial Intelligence (AI) has shown promise in both assessing and supporting interventions for individuals with ASD. The present article reviews the multifaceted relationship between ASD and AI, including assessment, emotional recognition and regulation, social skills training. Concerns regarding accessibility, ethical use, and oversight are discussed.

Keywords: *Autism Spectrum Disorder, Artificial Intelligence, assessment, intervention.*

1. Autism Spectrum Disorder: Diagnosis, characteristics and prevalence

Autism spectrum disorder (ASD) is a complex, life-long, neurodevelopmental condition characterized by challenges in social communication and repetitive behaviors. Although the causes of autism are not yet understood, there are risk factors that have been identified, such as low birth weight, having a sibling with ASD, parental age, and certain genetic conditions (National Institute of Mental Health, 2024). The ASD spectrum is broad, with individuals exhibiting a wide range of difficulties in several areas of life. Such deficits can significantly impact daily functioning, adaptive behaviors, and social interactions. Depending on the severity of deficits in communication as well as restricted and repetitive patterns of behaviors, severity of ASD is expressed in three levels, with level 1 being the milder form and level 3 the most severe (American Psychiatric Association, 2013).

The World Health Organization (2023) estimates that worldwide about 1 in 100 children has autism noting that for many middle- and low-income countries ASD prevalence is not known. The US Center for Disease Control (2023) reported that 1 in 36 children has been diagnosed with ASD. Prevalence has significantly changed between 2000 and 2020, with the identification rates increasing from 1 in 150 children in 2000 to 1 in 36 in 2020. It is important to note that the ASD diagnosis cuts across socioeconomic and racial strata, while it is four times more common in males than females.

Autism is usually diagnosed before the age of three. Research has shown that interventions which occur before or during the preschool years take advantage of brain plasticity and, therefore, can produce better and longer-lasting intervention effects. Beginning behavioral interventions and targeting other areas of development such as speech and language as soon as ASD is diagnosed, or even when ASD is suspected, leads to better outcomes (National Institute of Child Health and Human Development, 2021). Since early identification and intervention is key for best outcomes, knowing the signs is critical for parents and early childhood educators, in addition to clinical practitioners (CDC, 2023).

2. Artificial Intelligence and autism screening

Given the multiple and multi-faceted benefits of early intervention, using technological advances to expedite and improve the accuracy of ASD diagnosis is of paramount importance. Artificial Intelligence (AI) has been increasingly discussed as a critical contributing tool in health and mental health diagnostics. Given the complexity of diagnosis and the volume of information to be taken into consideration, AI can significantly contribute to the identification of ASD. Additionally, it can address a lack of trained specialists who are able to diagnose individuals with ASD, something that currently exacerbates the existing delays in diagnosis (Cavus et al., 2021).

Recent years have seen a sharp increase in the amount of research on the impact AI can have on the assessment and treatment of ASD. There are various AI forms contributing to diagnostics such as Machine Learning (ML), Natural Language processing, and Rule-based Expert Systems (Davenport & Kalakota, 2019). Machine Learning algorithms can analyze behavioral patterns and identify signs of autism in children. The model receives input data that it cleans and extracts pertinent information. Subsequently, the model ranks the extracted features, organizes, and classifies the inputted data accordingly (Barua et al., 2022). AI algorithms can assist clinicians in analyzing biological markers and behavioral patterns such as speech patterns, eye contact, gestures, and facial expressions to identify specific traits associated with ASD (Pandya et al., 2024). It's important to note that artificial intelligence models are often still inscrutable and complex, even to their creators (Mahmud et al., 2022), and that the effectiveness of these models is based on the data that is inputted which may not comprehensively inform any given model (Anagnostopoulou et al., 2020).

2.1. AI diagnosis and screening for ASD

AI tools have increasingly been used to shorten the assessment process for ASD by utilizing data from traditional ASD assessments and MRI results (Anagnostopoulou et al., 2020; Song et al., 2019). Cavus and colleagues (2021) found that ML models which utilized behavioral measures had higher rates of diagnostic accuracy than those that used MRI measures. These shortened assessments have also proven to yield equally or even more accurate results than traditional methods (Anagnostopoulou et al., 2020; Erden et al., 2021; Joudar et al., 2023; Megerian et al., 2022). Importantly, the shortened assessments have also allowed clinicians to decrease the age of diagnosis for ASD, creating earlier interventions and treatment (Joudar et al., 2023; Mahmud et al., 2022; Song et al., 2019). These shortened assessments decrease the cost of the diagnostic process, and thus have the potential to make such diagnostics more affordable to more people around the world. Mobile platforms also make it easier to implement through telemedicine, reaching rural and remote populations more easily (Megerian et al., 2022). Some scholars raise concerns that AI tools are an oversimplification of a nuanced assessment process (Song et al., 2019) and should not be a substitute for traditional assessment methods (Joudar et al., 2023). Other reservations regarding AI tools include viewing classification of ASD as binary, not capturing the complexity of the disorder (Cavus et al., 2021; Erden et al., 2021). Overall, findings to date are encouraging regarding AI assessment tools, though more testing and development is needed for a wider clinical picture (Cavus et al., 2021; Erden et al., 2021; Joudar et al., 2023).

3. AI interventions for ASD

To date, research has been focusing mostly on the use of AI in assessment of ASD, compared to interventions. Care for people with ASD is costly, with AI increasingly becoming an accessible and relatively cheaper alternative to traditional interventions (Ghosh et al., 2021). The effectiveness of such alternatives can be even greater for children with ASD as they have positive attitudes towards technology and they have shown increased motivation to use AI interventions (Mosher and Carreon, 2021). Particularly, human-robot interactions, AI-based gaming, and object-based visual graphics have been proven effective with individuals with ASD (Gosh et al., 2021). As people with ASD report high levels of comfort with technology, these AI advancements have the potential to allow individuals with ASD to live more independently (Ghosh et al., 2021; Mahmud et al., 2022).

3.1. Social skill development with AI for ASD

Empirical evidence consistently indicates that social-emotional competence is critical for healthy development and for counteracting the negative effects of exposure to contextual risks (Domitrovic et al., 2017). Being socially aware and applying interpersonal skills (e.g., listening, perspective taking, social problem solving) are essential for successfully interacting with others. Individuals with ASD display significant social skills deficits which adversely impact their academic achievement and relations with peers and adults (Silveira-Zaldivar et al., 2021). Using AI-based social skills training such as video modeling or virtual reality can be an efficient and effective approach (Hughes-Roberts et al., 2022). For example, Socially Assistive Robots (SARs) connect with virtual-reality activity platforms to enhance interactions and social skills. While much of this research focuses on the utilization of SARs with older adults, the few studies that have examined AI and social skill development for children with ASD have found it to be a beneficial way for these children to gain tangible skills.

3.1.1. Virtual reality and Socially Assistive Robots. A subset of AI is virtual reality (VR), which provides a realistic, safe, and controlled learning environment for children with ASD to practice skills free from negative consequences (Hughes-Roberts et al., 2022; Chaidi & Drigas, 2023). Specifically,

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virtual environments are free from distracting social stimuli; allow children with ASD to stay on task more easily; do not penalize children for wrong answers as it may be in the real world; and have a low risk of stigmatization, which in turn can result in improved autonomy and self-esteem (Chaidi & Drigas, 2023). In addition to the benefits of VR for children with ASD, initial reports indicate that interactions with robots also improve real-world social interactions. The significant potential of SAR use is that they can personalize social skills' support to enhance therapies already in place (Scassellati, 2007). Socially Assistive Robots, also offer the opportunity for caregivers and educators to be engaged in the intervention, further enhancing interpersonal interactions. In such interventions, SARs can adapt difficulty of activities based on past performance, model appropriate social skills, and encourage sustained engagement. For example, in a triadic, 30-day home-based intervention targeting social communication, a SAR modeled eye-contact and perspective-taking, behaviors with which children with ASD struggle. Children showed improvement in attention, and overall increased communication even when not in the presence of the SAR, a significant indication of generalizability of learned effects (Scassellati et al., 2018).

3.2. Emotional recognition and regulation with AI for ASD

Overall effective behavioral functioning includes both interpersonal (e.g., social skills) as well as intrapersonal (e.g., emotional regulation) characteristics (Domitrovich et al., 2017). There is a strong, positive relationship between emotional regulation (ER) and social skills; improvement in one area can reinforce improvement in the other (Restoy et al., 2024). Self-regulation is a component of Executive Functioning, which, when operating efficiently, coordinates various cognitive processes to select and apply socially-appropriate behaviors in various circumstances. Individuals with ASD struggle with ER, show significantly more maladaptive strategies, and fewer adaptive ER strategies compared to their non-ASD counterparts (Restoy et al., 2024). Socially Assistive Robots can provide useful AI interventions for individuals with ASD because they express emotions in relatively basic ways compared to traditional human emotional expression, thus limiting sensory overload. Interactions with SARs have been shown to improve attention, ability to identify emotions, and development of social competence in children with ASD (Cano et al., 2023). In addition, SARs have been used to encourage children with ASD to express their thoughts and emotions either verbally or non-verbally. In such scenarios, SARs provide immediate feedback, validation, and enhance responses. Other studies have explored the use of smartwatches and biofeedback to provide ER interventions. For example, a computer application monitors the wearer's heart rate through their smartwatch, and if the rate exceeds a certain level, the smartwatch vibrates and provides pictograms of copying strategies for the user to apply. Over the course of few days, participants were able to self-regulate in less time than before by applying appropriate regulation strategies (Torrado et al. (2017). Research on AI and emotional recognition and regulation for those with ASD is not as extensive as that on assessment and diagnosis, but it is increasing rapidly, and as more data are collected to enrich AI input, the capabilities of these tools will be further refined.

3.3. AI applications supporting educators working with ASD students

Traditional teaching methods for students with ASD are time-consuming and slow-paced to produce results (Barua et al., 2022). They also vary in effectiveness depending on the individual applying them. As discussed in previous sections, AI applications show significant promise to enhance the social and emotional learning of students with ASD. AI and VR tools are most effective for students with ASD when they are first introduced by a teacher who is able to walk the student through the expectations prior to implementation (Hughes-Roberts et al., 2021; Mosher & Carreon, 2021). In their 2021 study, Lampos and colleagues assessed more than 5,000 interactions between a teacher and seven students with ASD to create a ML model that was able to effectively predict what type of teacher communication would yield a positive student response. Similar AI educational tools have been reported by parents and educators as being effective for teaching students with ASD (Barua et al., 2022). AI is capable to detect learning patterns in ASD students and tailor interventions accordingly, offering pointed, personalized interventions that can enhance teacher strategies (Mahmud et al., 2022). Anecdotal evidence from the field also includes the use of open AI platforms such as ChatGBT offering critical support for the daily adaptive functioning of individuals with ASD such as to create social stories and lists of steps for completing various tasks. Research on the application of AI to support educators working with ASD students is still limited, but it is clear that there is a great potential for AI use in educational settings.

4. Challenges and limitations to Artificial Intelligence and ASD

The potential of AI tools for delivering individualized interventions, targeting specific skills is exciting. Artificial Intelligence applications are not a replacement for educators, therapists, and other specialists, but a tool to enhance supports for individuals with ASD. As groundbreaking as the strides in

AI-based approaches to ASD diagnosis and intervention are, there are key limitations that make it difficult for AI to currently be adopted more broadly. Perhaps the largest limitation of AI in ASD assessment and treatment is the lack of availability of large quantities of quality data. Research on ASD does not produce the same quantity of data that research in other medical conditions yields, limiting AI models, as the more data an AI model is provided, the better the results (Erden et al., 2021; Joudar et al., 2023). Issues have been raised regarding the complexity of input required in order to address the multitude and diversity of ASD symptoms in each case. Since AI models do not respond to inputs autonomously, but rather they still primarily respond in predetermined ways based on data (Cano et al., 2021). Therefore, reliance on existing datasets makes it difficult for such tools to be personalized to individual users (Barua et al., 2022). It must be noted that although AI contributes to minimizing biases, such as gender or cultural, that diagnosticians and educators may display, it does not yet have the capacity to address the nuances involved in working with individuals with ASD. Whereas a clinician or educator may assess individual cases based on a variety of shifting factors and tailor their interventions accordingly, an AI tool will assess a case based on previous cases and will have a given set of intervention options (Erden et al., 2021).

When data use relates to humans, ethical concerns around privacy are raised. Data collected for AI-based ASD tools are sensitive, especially for a population that is vulnerable to discrimination. Many researchers have raised concerns about the viability of data protection for these emerging tools (Erden et al., 2021; Joudar et al., 2023; Mahmud et al., 2022; Song et al., 2019). Another consideration for AI development is the cost. Artificial Intelligence applications are still a relatively new intervention in healthcare and the tools are expensive to purchase and maintain (Joudar et al., 2023; Mahmud et al., 2022). The cost of the tools and their maintenance will likely decrease as the tools become more mainstream, but during the experimental and early stages of adoption, cost is cited as a concern for effective implementation.

Lastly, given the complexity of this topic, there is a pressing need for coordinating and combining information across multiple fields involved in the investigation of AI and ASD in order to address it most effectively (Mazzocchi, 2019). Research on this broader topic is produced by several fields such as computer & mechanical engineering, education, human development & exceptionality, informatics, medicine, robotics, and psychology to name a few. Multi-, inter- and trans-disciplinary research in ASD and AI has the potential to produce more comprehensive and applicable interventions to address the academic, social, and emotional needs of individuals with ASD.

5. Conclusion

Individuals with ASD struggle with their intrapersonal and interpersonal skills, which significantly affect their learning, daily functioning, and overall quality of life. The earlier they are assessed and receive interventions in various areas of development, the better the prognosis for school adjustment and transition to post-secondary life. Although in its early stages of use with individuals with ASD, AI can assist in delivering early and consistent interventions. As AI tools become more refined, such applications show tremendous promise in the diagnosis, assessment, as well as clinical and educational interventions.

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