VIRTUAL REALITY AS AN EFFECTIVE SOCIAL SKILLS TRAINING PLATFORM FOR IMPROVING SOCIAL AND BEHAVIOURAL INTERACTIONS OF AUTISTIC CHILDREN: A NARRATIVE REVIEW

BEN CAPUTO*[1], JOY CHOWDHURY*[1], KARISHMA MEHTA*[1], HELENA SON*[1]

[1] BACHELOR OF HEALTH SCIENCES (HONOURS), CHILD HEALTH SPECIALIZATION, CLASS OF 2025, MCMASTER UNIVERSITY
**ALL AUTHORS CONTRIBUTED EQUALLY*

ABSTRACT

Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by challenges in socio-pragmatic interactions and repetitive behaviors. Current research supports the use of tailored behavioral interventions to effectively enhance the well-being of Autistic individuals and their families. Traditional social skills training (SST) is a commonly used intervention in addressing social and behavioural deficits often associated with ASD. Given the barriers faced by autistic individuals when accessing traditional forms of SST, researchers have begun to investigate alternative, more accessible delivery mediums, including virtual reality (VR). The aims of this review are twofold: (1) to investigate whether VR is an effective tool through which SST can be delivered to autistic individuals; (2) to determine the impact of VR environments on the real-world social interactions of autistic children when used as a platform for SST. The results of this study demonstrate that VR is a promising, dynamic, accessible, and effective practice for the development and support of a range of social skills in ASD individuals.

Keywords: autism spectrum disorder (ASD), virtual reality (VR), social skills training (SST), social skills, emotion regulation, cognitive skills

INTRODUCTION

Defining ASD, Symptomatology, Etiology, and Prevalence

Autism spectrum disorder (ASD) is characterized by deficits in social communication and the presence of repetitive behaviors, interests or activities, as outlined in the DSM-5 [1]. The risk of ASD can be partially predicted through genetic factors, which also results in greater incidence in males [2]. As of 2023, ASD affects approximately 0.72% of the global population, though underdiagnosis remains a concern, particularly in developing regions [3]. In this article, we use "autism," "autistic individuals," and "ASD" interchangeably, aligning with a growing body of literature that discourages person-first language due to its potential to increase stigma [4].

Educational Interventions and ASD Treatment

At present, there is no singular accepted treatment for ASD. However, current literature supports the application of individualized behavioral and educational programs to positively impact the lives of autistic individuals and their families. As autistics' relational modalities appear one-sided, assistance in forming relationships is needed [5]. Studies have demonstrated that autistic individuals can learn to act in social situations if they have the opportunity to regularly participate in scenarios that mimic common daily interactions [6-8].It has also been shown that traditional educational interventions (e.g. social skills groups, video modeling, peer-mediated instruction) [9] for individuals with ASD can be expensive, inaccessible, and inefficient as a result of limited resources and low motivation on part of the individual [10,11].

Social Skills Training and Symptom Management

Traditional social skills training (SST) is a common intervention to help address social deficits associated with ASD [12]. This behaviour therapy involves modelling social interactions through face-to-face interventions to improve communication skills. These programs primarily rely on interactions between the child and a facilitator to reinforce positive social behaviours. In therapies involving operant conditioning, direct and explicit directions are provided to reduce repetitive or restrictive behaviours. This approach can increase skills

(e.g. eye contact) which may be utilized in realistic social settings [13]. Due to the wide variety in symptomatology with ASD, the types of appropriate social skills training can vary with the age and functioning level of the individual. Current SST involves pivotal response training or prompts from facilitators supplemented with environmental modifications. SST can also involve interactions with other children through peer mentorship and with peers in large groups [14].

Application of Virtual Reality in Social Skills Training

Technology-driven therapies for ASD, including robotics [15-17], mobile apps [18-20], interactive video modeling [21-24], and virtual reality (VR) [25,26], are rapidly increasing in popularity. Autistic individuals in particular have shown interest and adherence towards learning through computerized programs, such as VR, due to its capacity to change environments and modulate to specific sensory levels. VR technology aims to create an interactive computer-generated virtual environment by combining hardware and software to provide individuals with the feeling of presence and an immersive environment [27]. Favourable properties of VR include cost-effectiveness, as evidenced by numerous quantitative evaluations of VR-based therapies as compared to traditional therapies, across various phycological disorders [28, 29, 30, 31]. Another favourable property of VR is the high self-determination index (SDI) for autistic individuals to engage in this form of SST. SDI is determined by subtracting mean external motivation from mean internal motivation. Therefore, since autistic individuals tend to have a higher mean internal motivation towards VR technology, they will be more likely to engage in VR-based SST [32]. Finally, the relative accessibility of VR has produced a large body of research targeting autism-related disabilities with this technology [33-36].

As such, this review focuses on the impact of VR-based SST on autistic children in North America. Traditional SST methods remain expensive and resource-limited [37], while VR offers a promising, scalable alternative. Given the cultural variability in ASD presentation, we examine VR's role in facilitating social development in North American children and its potential as a future ASD treatment [38].

METHODS

Literature was collected by conducting targeted searches on databases including Ovid Medline, PubMed, Web of Science, and CINAHL using a range of key terms.

EFFECTIVENESS & EFFICACY OF VR USE IN SOCIAL SKILLS TRAINING FOR AUTISTIC YOUTH

VR is a promising, dynamic, accessible, and effective practice for the development and support of social skills in ASD individuals [14,39]. A systematic review and meta-analysis by Karami et al. on the effectiveness of VR for the rehabilitation and training of ASD individuals [39] found that VR held varying degrees of effectiveness when targeting different social and life skills. From reviewing 26 uncontrolled and nine controlled trials, the authors concluded that "VR technology can be a viable tool for designing interventions aimed at enhancing and improving different skills" in autistic people at any age. The results of their analysis found the strongest effect of VR on improving daily living skills (i.e. shopping, driving, street crossing, and job interview skills), while moderate effects of VR were found in improving cognitive skills (i.e. attention and concentration, reasoning and problem solving, executive function, language, and metacognition), emotion regulation and recognition skills (i.e. emotion expression, affect recognition, stress, and anxiety management), and social and communication skills (i.e. social adaptation and interaction, communication, social reciprocity, social responsiveness, negotiation skills, and theory of mind). The same paper also found that performance on tests evaluating the aforementioned skills improved as age increased, but observed a substantial decline in the effectiveness of VR training on individuals diagnosed with some form of comorbidity alongside ASD. Ultimately, the results of the study showed promising efficacy of using VR in the various skills training of autistic individuals when compared to more conventional training programs, particularly when used to improve the effectiveness of daily living skills.

Another systematic review by Satu et al. on the use of immersive VR in neurodevelopmental disorders [40] found that immersive VR was mostly used in connection with ASD for the assessment of and intervention in social skills. From a review of 34 studies, the authors found that ASD intervention studies focused primarily on addressing social communication (i.e. improving nonverbal communication and social interaction, verbal and social communication, emotional and social adaptation skills, recognition of basic emotions and social skills, and joint attention skills); their results suggest that immersive VR "makes it possible to practice complex social skills in a controlled situation close to daily life." Erb, in their scoping review on the use of VR and augmented reality (AR) to teach various skills to children and youth with comorbid ASD and intellectual disabilities (ID), [41] further asserts that VR facilitates this practice because autistic individuals can practice their socio-emotional skills in a highly individually-relevant environment, without the "fear, anxiety, and potential consequences of real-life." [41] The review of 20 studies found that (given that autistic children and youth diagnosed with both ASD and ID typically demonstrate difficulties in initiating and maintaining social interactions) the use of VR and AR technology has been found to be a useful medium through which autistic individuals can practice various skills by simulating "real-world experiences in a safe and controlled

environment." [41] It is important to note, however, that the addition of AR adds complexity to the accessibility of this technology, particularly when compared to VR technology only. This can have further implications for the accessibility of VR / AR technology and social skills training for Autistic youth. [42] Overall, Erb concluded that the use of VR / AR demonstrated positive results with respect to teaching autistic individuals social skills, in addition to the generalization of such skills to real-world scenarios [41,43].

In conclusion, the exploration of VR as a tool for the rehabilitation and training of ASD individuals reveals promising avenues for enhancing various skills crucial to daily life. The remainder of this paper will investigate the effect of VR usage in addressing different basic and complex skills relevant to ASD.

APPLICABILITY OF VR IN SYMPTOM MANAGEMENT FOR ASD

The purpose of this section is to define some of the most common phenotypes and symptoms associated with ASD and how VR can be utilized as an alternative measure of treatment. We investigated whether VR could improve the measure of various symptoms over time, and whether there was a significant difference when compared to traditional, in-person forms of SST.

Stereotyped or Repetitive Motor Movements (stimming)

Stimming is a core characteristic or symptom that dictates the diagnosis of ASD [44]. The effects of stimming can affect real-world social interaction through repetitive motor movements and repetitive verbal language [44]. Stimming is defined as repetitive and unregulated motor movement [45]. Unmanaged, it can hinder engagement in activities, often requiring intervention [45]. Enriching the child's environment has been found to be an effective method for practitioners and parents to reduce stereotypic behaviour in some children. This is most successful when there is a strong match between the sensory input provided by both the alternative and original stimuli [46]. In this case, VR technology provides stimuli meant to mimic real-world social interaction, which is the original stimuli. As VR technology advances and becomes more realistic, the gap between social interactions in VR vs. the real-world becomes smaller. Hence, virtual reality can be an effective tool for the management of stimming, since its immersive qualities can match the sensations felt from both stimuli.

A review from Chen et al. explores the efficacy of VR technology for social skill development in autistic. The study found that VR provides ASD individuals an inexpensive medium to learn, a motivating environment to practice skills, and a personalized setting where learners feel safe due to it being a controlled, familiar environment [47]. Another study by Frolli et al. found VR could decrease stimming but reported no significant difference between traditional SST and VR groups in reducing these behaviours [14].

Abnormalities in Eye Contact

One of the most common ASD symptoms is difficulty maintaining eye contact. Autistic children tend to have atypical viewing patterns because they show a greater fixation towards nonsocial objects than humans face during social interactions [48]. Evidence suggests that individualized interventions like VR immersion can address core vulnerabilities related to the lack of eye contact for ASD individuals. A study by Lahiri et al. found that VR provides a lower-anxiety platform for practicing social interactions, leading to a significant increase in the time spent fixating on faces among adolescent participants. Furthermore, this article also highlights that VR can be used to communicate with individuals from different parts of the world, which can improve eye contact when socializing with others from diverse backgrounds [49].

Deficits in Emotional Expression and Recognition

ASD is typically characterized, among other criteria, by deficits in social-emotional reciprocity [49,51]. These deficits often manifest as the reduced sharing and expression of emotions, as well as difficulty recognizing and interpreting the emotions of others [50-52]. Through social skills training and operant conditioning, autistic children are trained to associate facial expressions to specific emotions. According to a study by Didebhani et al., VR-based interventions may be able to improve the ability of children to recognize the emotion of others through facial expressions and tone of voice [53]. In this study, thirty children between the ages 7-16, completed two hours of VR training every week for five weeks, and had their emotion recognition skills observed. The results showed that VR resulted in an increase in emotion recognition, social attribution, and executive function of analogical reasoning, which suggests that VR interventions are effective for improving social impairments associated with ASD [53]. A study by Yuan et al. explored similar topics, investigating the efficacy of a VR-enabled training program on social and emotional skills for primary school autistic children. After six 1-hour training sessions, the authors found significant improvements in emotional expression and regulation, as well as a significant positive effect on social reciprocity [54]. Finally, a study by Frolli et al. compared a traditional emotional training procedure performed with a therapist to a training procedure that was VR-based [14]. The findings suggested that VR-based and traditional interventions have similar acquisition times for the recognition of primary emotions. Moreover, the VR-based intervention even showed shorter acquisition times for tasks requiring the use of both primary and secondary emotions. Overall, these collective findings support VR-based interventions as a promising asset to traditional emotional training and therapy methods.

Absence of Interest in Peers

Displaying little to no interest in other children has long been identified as a behaviour that can help differentiate autistic children from those without, especially in early years of life [55]. Moreover, ASD individuals have been found to be less likely to initiate social interactions with same-aged peers [56,57]. These behaviours can persist throughout an autistic individual's lifespan, and result in the inability to create stable friendships or relationships [58]. A recent exploratory study conducted by Ke et al. found that a VR-based social skills training program could lead to an increased level of social skills performance in autistic children, including significant improvements in the frequency and success of social interaction initiation [59]. This study provides preliminary evidence supporting the usage of VR-based interventions to increase social interest and engagement in autistic children.

DISCUSSION

Benefits of VR Interventions

VR interventions are crucial to SST for autistic children as they not only facilitate a safe, low-risk environment, but they increase engagement and help with the generalizability of said social skills to real-life scenarios. A traditional behavioural skills training intervention called video modeling is a type of observational learning where a person (an adult, a peer, or the student themselves) is recorded engaging in the targeted social skill (e.g., waving, putting up their hand in class, playing with their peers). Children who need to improve on those social skills will watch these recordings with a facilitator who will point out the important social skills presented as well as answer any questions [60]. While this has been an effective SST intervention [61] for teaching new behavioural skills in similar environments, it is not a sufficient long-term SST intervention because it does not effectively help children apply these behaviours when presented with a context different from the rehearsed task scenario [62]. This ineffectiveness of the intervention is emphasized in autistic children as they have a decreased ability to generalize knowledge from one context to another [62]. Thus, VR interventions are being explored to address this limitation.

Since VR tools inherently use electronic devices, it is important to highlight previous research on autistic children's relationship with technology in the context of learning and education. Computer-assisted instruction and electronic screen media (e.g. animated programs)[10] have been shown to be more accessible for autistic children as a majority of autistic children show comfortability with technology as well as show a reduction in 'problem behaviours' when using technology, allowing them to have an increased level of engagement with these types of interventions [63]. Additionally, ASD individuals might prefer the characteristics of computer-generated speech (e.g. monotone, less variable) because of their desire for "sameness." [63,64] Although advancing VR technology may introduce more varied voice outputs, the controlled environment of VR still provides a structured, low risk setting for SST.

In addition to the high motivational index that is created when using VR interventions for ASD individuals, virtual environments can encourage flexibility and generalizability by providing real-life role-play situations. In a pretest-post test study, Didehbani et al. investigated a group of autistic children immersed in VR-based social skills training involving role-play with avatars in daily life social scenarios. The results showed an improvement in the following measured outcomes: emotion recognition, social attribution, and executive function [53]. The study also mentioned how these VR interventions provide a platform for repeated practice of the same behavioural/social skills across different scenarios. The need for learning various applications of the same social skill is essential and can be accomplished with VR tools as they move away from rote learning and help facilitate the generalization of social skills from those learned in VR to those used in daily interactions [53]. While concerns exist regarding technology-based interventions promoting social isolation, research suggests that interactive behavioural intervention technologies like VR offer flexible, generalizable social skills practice in a safe setting for ASD individuals [25,66,67].

Limitations of VR Interventions

While the use of VR holds many benefits, it may also present its own limitations. Difficulties in accessing VR interventions, such as financial barriers / startup costs (e.g. purchasing softwares, headsets, controllers) and ongoing expenses related to maintenance, upgrades, and technical support, may pose barriers for some schools and families in accessing these interventions. Additionally, the individualized, "no-one-size-fits-all" nature of ASD means that interventions effective for one child may not necessarily be effective for another; this may make it challenging to create universally beneficial VR programs for social skills training for all ASD individuals. There is also a concern about the potential for overreliance on VR as a sole intervention method, which could limit exposure to diverse social situations and interpersonal dynamics that are essential for holistic social development. Further, the effectiveness of VR-based interventions may be influenced by factors such as the child's comfort level with technology, sensory sensitivities, and cognitive abilities, which need to be carefully considered and addressed in the design and implementation of VR programs for ASD individuals. Despite these limitations, ongoing research and advancements in VR technology offer opportunities to refine and tailor interventions to better meet the needs of ASD children and improve their social skills development.

Looking ahead, the integration of emerging technologies such as artificial intelligence (AI) and brain-computer

interfaces (BCIs) could further enhance VR-based SST interventions. AI-powered VR could create adaptive learning experiences by responding dynamically to a child's progress, providing personalized feedback and adjusting scenarios in real time based on behavioral cues. AI-driven emotion recognition can also enable virtual avatars to display naturalistic facial expressions, tone, and social cues, making social interactions more authentic. Meanwhile, BCIs could revolutionize VR interventions by offering deeper insights into neurological responses during social training, allowing for highly personalized interventions tailored to individual cognitive and emotional needs.

While these advancements hold promise, they also remain susceptible to many of the current limitations facing VR technology today, including accessibility-based and ethical concerns. Nevertheless, ongoing research and technological innovations continue to refine the capabilities of VR in social skills training, offering exciting opportunities to improve interventions for autistic individuals.

CONCLUSION

The studies reviewed in this article underscore VR's efficacy in improving social, cognitive, emotional regulation, and daily living skills among autistic individuals across different age groups. VR's ability to simulate real-life scenarios in a controlled environment offers a safe and effective platform for practicing and generalizing socio-emotional skills. The accessibility and motivational appeal of VR hold great potential for addressing the challenges faced by ASD individuals, particularly when traditional interventions prove costly, inaccessible, or inefficient.[9] Some of the primary barriers to accessing traditional forms of social skills training is the need for facilitator, accessibility/requirements of a clinician, transportation, and time-intensive training, which can be addressed by the use of VR [12].

Initiatives aimed at integrating VR into educational curricula and therapeutic interventions may provide opportunities for schools and families to access funding specifically designated for acquiring VR technology. Future research should aim to explore the long-term effectiveness of VR interventions for autistic individuals, as well as investigate the optimal methods of incorporating VR into existing therapeutic practices and educational settings [68]. This research will not only contribute to the optimization of VR-based interventions, but also enhance our understanding of how technology can best support the diverse needs of ASD individuals across different developmental stages and functional levels.

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