

Virtual Reality: implications in Autism Spectrum Disorder

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Abstract

Autism Spectrum Disorder (ASD) is a neurodevelopmental disease that is specially characterized by impairments in social communication and social skills. In the last decade, there has been an increase in publications on technology-based interventions for autism spectrum disorder (ASD). Virtual reality (VR) has emerged as an effective tool for intervention in the health field. Different recent papers have reviewed the VR-based treatments in ASD. Virtual reality based assessments and intervention tools are promising and have shown to be acceptable amongst individuals with ASD. This scoping review reports studies utilizing virtual reality and augmented reality technology in social skills interventions for individuals with ASD. Our review suggests that there is need for studies that apply virtual and augmented reality with more rigorous designs involving established and evidenced-based intervention strategies. The studies examined suggest moderate evidence about the effectiveness of VR-based treatments in ASD. VR can add many advantages to the treatment of ASD symptomatology, but it is necessary to develop consistent validations in future studies to state that VR can effectively complement the traditional treatments.

Keywords

Virtual Reality, ASD, Autism Spectrum Disorder; Social Skills; Practical Skills

1. Introduction

In more recent years, an increasing number of studies on virtual reality (VR)-based training and therapy have established good evidence on its facilitation of traditional approaches. VR simulates different senses for an immersive experience. Its use in psychiatric and developmental disorders has been increasingly explored. The development of virtual reality environments (VREs) offers a promising training tool for immersive computer-generated virtual worlds. Since the first use of virtual reality (VR) in 1987, many different definitions of virtual reality (VR) have appeared in the literature. An interesting recent definition [1] defines VR as "an artificial environment experienced through computer-provided sensory stimuli (such as images and sounds) and in which a person's actions partially determine what happens in the environment". Broadly speaking, VR includes some interactive video games, virtual environments, and general multisensory experiences. In recent years, we have seen a steady increase in the prevalence of autism spectrum disorder. In this regard, it is increasingly felt the need to have reliable knowledge about the effects of different types of interventions. In recent years several research synthesis and guidelines for the diagnosis and treatment of autism have been developed by international

Proceedings of the International Day of Persons with Disabilities. Inclusion, Autonomy, Technology, December 2–3, 2022, Rome, Italy
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CEUR Workshop Proceedings (CEUR-WS.org)

research, while the knowledge on the use of technology in pedagogical contexts is more fragmented. The majority of them adopt the systematic review method for evidence synthesis and focus on a specific well-defined topic, including the effectiveness of VR intervention on a certain type of skill, such as attention detection, social functioning, or abstract concept and imagination. VR has emerged as an effective new treatment approach in different areas of the health field, such as rehabilitation [2,3], promotion of emotional wellbeing in inpatients [4,5], diagnosis [6,7], surgery training [8,9] and mental health treatment. With regard to mental health treatment, VR is used in the treatment of a wide range of disorders: Phobias, post-traumatic stress disorders, obsessive-compulsive disorders, and, of course, ASD. Specifically, in this intervention area, VR has shown some advantages, allowing ASD patients to be trained in a realistic environment that could be manipulated and adapted to the characteristics and capabilities of the subject. It has been related to the ecological validity of treatments of this type in a controlled environment [10]. Autism spectrum disorder (ASD) is a developmental disorder characterised by persistent impairment in social communication and patterns of repetitive behaviours [11]. Social stories are useful in teaching children with ASD about social situations and formulating socially appropriate responses [12]. It minimises potentially confusing instructions by providing direct social information, followed by new skills practices. Traditionally, social stories are presented on paper, as a recording or as a video, followed by role-play or subsequent practices. However, not all social situations could be well-practiced in real life. For example, it is not safe and humane to have a pedestrian crossing the red light in real life to teach children the right behaviour and appropriate responses. However, such situation could be programmed into a VRE, providing a safe, controllable environment to practice skills repeatedly. A recent meta-analysis revealed that innovative technology interventions have a moderate effect ($d = .047$) in the post-tests of the targeted skills in children with ASD, supporting the development, research and clinical use of such intervention [13]. This introduction provides a synopsis of the use of newly-emerging VR technologies as educational and interventional tools for the ASD population. Grounded in mainstream rehabilitation and education theories, platforms and equipment based on VR technology show advantages in training of social communication and interaction skills. Evidence-based practices demonstrate that incorporating VR into therapy or training programs is effective in improving the social aspects of performances among individuals with ASD. Studies have suggested several reasons for the special interest that people with ASD appear to have in computerized learning [14; 15] and have identified the advantages that computers provide with respect to the core deficits of ASD. These include the consistency of a clearly defined task and the usually specific focus of attention due to reduced distractions from unnecessary sensory stimuli [16]. Technology usage dedicated to ASD has gone considerably beyond the use of simple desktop computers. This now includes the use of robotics [17], interactive video/DVD [18], handheld and touch pad devices [19], Internetbased collaborative virtual environments [20], and shared active surfaces [21]. Specific technologies such as authoring software tools, video modeling and video self-modeling, speechgenerating devices, and virtual reality have been evaluated to determine their effectiveness as intervention strategies for promoting social, functional, and behavioral skills in individuals with ASD.

2. Autism: the definition

Autism spectrum disorder (ASD) is a complex neurobehavioral disorder that involves impaired social interaction, verbal underdevelopment, problems with communication skills, and challenging and repetitive behaviors; ASD has a wide range of symptoms [22]. About 1 in 68 children are diagnosed with autism, and boys are more likely to have ASD than girls [23]. People with ASD have different cognitive and intelligence profiles than ordinary people [24, 25]. Several studies have shown that most children and adults with ASD have delays in their cognitive skills [26, 27]. Increasing awareness about cognitive phenotype will help to understand the better relationship between genes, brain, and behavior

and provide more information about treatment methods. Given the challenges that exist in improving the health status of children and adults, paying attention to emerging approaches to improve cognitive abilities seems to be a way forward. Cognitive rehabilitation includes a wide range of treatment methods that can be performed by different rehabilitation specialists [28]. Already at an early age, individuals with autism show tendencies of orienting themselves mostly to non-social stimuli, at the expense of social stimuli, and this orientation can have cascading effects on their social and linguistic development [29]. The preference for non-social stimuli and restrictive behavior might be related to challenges for individuals with autism when encountering society. Individuals with autism commonly have lower quality peer friendships with fewer reciprocal relationships and lower acceptance by their classmates [30]. Difficulties individuals with autism experience in educational settings are often related to making sense of social stimuli and unpredictable social environments [31].

3. Virtual Reality Interventions

Virtual technology refers to the technology that intends to imitate a physical world. This imitation is developed through the simulated or digital world by constructing a sensory feeling. Accordingly, this technology can create a sense of reality in people. There are three primary categories of virtual reality simulations, which include non-immersive, semi-immersive, and fully-immersive simulations [32]. All types of virtual technology are beneficial for sciences such as telemedicine, robot development, and computer-based rehabilitation [33]. VR has been used in a wide variety of interventions, ranging from the treatment of phobias to interventions aimed at improving false belief understanding. VR interventions have also been used in an array of interventions aimed at individuals with autism spectrum disorders (ASD), such as improving the understanding of social rules and norms.

3.1 Practical Skills

There are several studies that investigated the efficacy of VR intervention on individuals' practical skills. McDougle and Accordino refer to practical skills as the skills needed to function independently in everyday life, such as riding the bus [34]. In the study by Adjorlu et al, the authors sought to evaluate the feasibility and effectiveness of VR to train shopping skills in individuals with ASD [35]. Training consisted of the participants retrieving four items as specified on a shopping list from a virtual supermarket. Outcome measures were recorded before and after the training sessions, and were conducted similarly to the VR training, but in a real supermarket. The treatment group reached 100% effectiveness in both the pre and post assessments. Adjorlu and Serafin investigated whether VR is a feasible and effective way of improving money skills in individuals with ASD [36]. Sessions consisted of three levels of training, with increasing complexity, all centred around paying the correct amount of virtual money. The outcome measures were measured in real life, pre and post intervention, by presenting students with price cards and asking them to pay the correct amount of real money as indicated on the price card. The authors found that four out of the five participants improved their money skills, although with some degree of variability.

3.2 Social Skills

Social skills may be understood as the life skills that concern themselves with the social abilities needed to function in everyday life [37]. The social communicative impairments defining the disorder makes social skills an important target in educational interventions [38]. In this review, we broadly define sociability as behaviors that are performed in social settings and involve interpersonal interactions [39]. This engagement is not limited to on-site human-to-human interactions, as we also include human-machine interactions (e.g., interactions with robotic avatars, etc.). Technologies such as virtual reality (VR) appear promising for social skills training [40], representing a cost-effective approach to meeting the social and ultimately educational needs of individuals with autism. VR technology showcases artificial environments that can simulate real-world scenarios by using realistic imagery or can create visual and auditory stimuli around the end user's other senses. Beach and Wendt investigated whether a VR environment could be used to improve social interaction skills in individuals with ASD [41]. Two participants were recruited from a group of students attending a summer camp in the US that aimed to allow students to practice their social skills, and the study was conducted while the students were attending the summer camp. Participants were given tailored training in VR, which was adjusted to meet their specific social challenges. Generally, the authors reported positive results, with both participants improving their specific trait in need of improvement, as well as their general social interaction abilities, as observed by the camp teachers. Cheng et al investigated the effectiveness of a VR social understanding system in improving the social understanding and skills of three children with ASD [42]. These training sessions included virtual classroom and bus stop environments where participants were asked problem-based questions about nonverbal communication, social priming, and social cognition. The authors report that the data points were 100% non-overlapping, indicating that the treatment was effective in improving the skills examined. Ravindran et al. evaluated the effectiveness of a VR joint attention module in improving joint attention skills in people with ASD [43]. The sessions consisted of a Safari-themed virtual environment in which participants practiced joint attention with their virtual avatars by following established goals outlined in various flashcards. Findings indicate that there was an improvement in at least one area of joint attention skills for 10 out of the 12 participants.

3.3. Emotional issue and motivation to treatment

Patients with ASD often experience anxiety and fear of unfamiliar situations [44, 45]. Frequent turnover within the rehabilitation team and children with ASD are often uncooperative, leading to possible delays in the rehabilitation process and increased difficulties for medical personnel [46,47]. The VR environment has the advantages of safety, controllability, and repeatable operation. Its immersive image makes children with autism receptive to visual stimuli, which is beneficial for cognitive learning [48,49]. In addition, social stories are presented in the form of virtual animation, which is usually easy to arouse children's interest and immersion in animation, and maintain attention for a long time [50-53]. With these benefits, using virtual training can help further improve a child's cognitive abilities.

We can resume these interventions in table 1.

Table 1
Interventions described in this review

Authors	Aim	Training	Result
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Adjorlu et al.	VR could improve practical skills like going shopping in people with ASD	Training consisted of the participants retrieving four items as specified on a shopping list from a virtual supermarket.	The treatment group reached 100% effectiveness in both the pre and post assessments.
Beach and Wendt	VR environment could be used to improve social interaction skills in individuals with ASD	Training consisted in VR session of a typical social situation in the summer camp	The authors reported positive results
Cheng et al.	VR environment could be used to improve social interaction skills in individuals with ASD	These training sessions included virtual classroom and bus stop environments where participants were asked problem-based questions about nonverbal communication, social priming, and social cognition.	The authors report that the data points were 100% non-overlapping, indicating that the treatment was effective
Ravindran et al.	the effectiveness of a VR joint attention module in improving joint attention skills in people with ASD	Training consisted of a Safari-themed virtual environment in which participants practiced joint attention with their virtual avatars by following established goals outlined in various flashcards	Findings indicate that there was an improvement in at least one area of joint attention skills for 10 out of the 12 participants.

4. Conclusion

We can underline how the use of VR could affect better the development of Autism. It improves social skills and practical skills. The number of studies found both in computer-related journals and autism related journals shows the need for a broad search in databases and journals when reviewing studies on VR/AR, and autism. Our review identified a higher number of studies than the previous reviews, indicating a rapid growth of research in this area. We suggest more studies in this direction with a focus on follow-up to generalize the effect.

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