Virtual Reality for Social Skills Training of Children and Adolescents with ASD: A Systematic Review

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Abstract. Autism spectrum disorder (ASD) is characterized by an inability to identify facial expressions and recognize other people's emotions. Individuals with ASD would struggle to give appropriate answers and have effective communication in social interactions. As a result, children and adolescents with ASD are vulnerable to isolation at school and have fewer opportunities to develop social relationships with peers. Virtual Reality (VR) has been studied and widely used in education for quite a long time. It is evidenced as an effective tool in social skills training for children and adolescents with ASD by improving their emotion recognition ability and social reciprocity. Furthermore, by imitating real-world circumstances, VR can provide repeatable social scenarios for ASD children and adolescents to explore safely. This paper followed PRISMA systematic review design to analyze imperial studies on social skills training for children and adolescents with ASD. A total of 276 participants were analyzed in the five selected articles from two hundred and fifteen records. The result showed that VR was effective and feasible for social skills interventions in all five studies.

Keywords: Virtual Reality; Children and adolescent; Autism spectrum disorder; Social skills.

1. Introduction

Autism spectrum disorder (ASD) is known as a life-long, neurodevelopmental disorder that can influence social communication and interrelationships with others [1]. Individuals with ASD show significant impairment in identifying facial expressions, and body postures for social interaction, and incapacitation in recognizing the emotions of others [2]. For autistic children and teenagers, slower emotion recognition greatly hinders them from responding appropriately to social interaction and makes them vulnerable to isolation [3]. As characteristic social deficits are common among adolescents and adults with ASD, they would struggle to navigate the complex situation in their daily life at school or in other interactive public places. While teaching ASD children and adolescents' social skills is essential, it can be challenging for both parents and teachers.

Virtual Reality (VR) refers to a type of technology that relies on computer programs to simulate the experience in a virtual or unreal environment by providing three-dimensional, real-time virtual space [4]. Research shows that VR as an innovative technology has been widely used both in education and health care for decades. There are a variety of ways to teach with VR, such as interactive video games, immersive learning caves, and desk-based computer software. In terms of special needs education, researchers made continuous efforts to combine VR with traditional teaching to satisfy different children with functional impairments. An early study in 1999 investigated experiential and communication virtual learning environments (VLEs) created for children with severe study disabilities [5]. Fonseca et al. focused on VR software for children with Down syndrome and indicated to provide a unique learning experience for children with special needs [6]. VR-based interventions were found to improve sustained attention effectively in a study that focused on child attention deficit hyperactivity disorder (ADHD) [7].

It is significant to note that numerous empirical studies have investigated the viability and efficacy of employing VR for instruction and intervention in the ASD group. Serious games, for example, a VR pink dolphin, were used to train ASD students' psychomotor skills and hand-eye coordination [8]. In a study by Self et al., the VR group required less time to learn how to react to a fire drill compared with the integrated treatment group [9]. Similarly, two studies noted the effectiveness of

teaching children living skills, including road-crossing and air travel in VR [10,11]. In addition to basic life skills, VR can also be helpful in training ASD youth to engage in complex scenarios with higher communication demands. An earlier randomized controlled experiment indicated that trainees with ASD could improve their interviewing abilities by receiving virtual reality job interviews.

Regarding social skills training, research shows that children and adolescents with ASD can enhance their social reciprocity and reduce social anxiety in VR settings [13,14]. A contextual, naturalistic intervention in a loose VR environment incorporates exactly the interests and preferences of the targeted children into the intervention activities [15]. By imitating real-world circumstances, VR enables ASD kids and teenagers to safely explore social situations that they may find difficult to handle in real life. A socially friendly virtual world could minimize the social anxiety caused by their inadequate expression recognition and lack of social reciprocity. Notably, the safe real-world scenarios created by VR can be reused and practised without limits.

Systematic reviews and Meta-analyses are critical tools for accurately and consistently summarizing the evidence. In recent years, there has been a rising interest in VR training for children and adolescents with ASD. However, when put into practice, VR is frequently hampered by limitations related to resources, expenses, and equipment. Particularly, applying VR to children and youth with autism is restricted by ethical concerns and experimental approaches. This study aimed to screen and analyze related research to 1) compare different studies in terms of methods and execution procedures for anyone interested in conducting studies in this area. 2) summarize the present status of research and evaluate the efficacy of VR to teach social skills among children and adolescents with ASD.

2. Methods

2.1 Data Collection Procedures

A preliminary search was conducted in October 2022 through the University of Edinburgh online library. By inserting the terms “VR” and “ASD” as “keywords” or appearing “anywhere in the record,” 215 results were selected automatically from twenty databases, most in Scopus (n=141). Search terms appeared in multiple variations in results, ASD for “Autistic Children,” “Autism,” “Autism Spectrum,” and VR for “Virtual Reality,” indicating that relevant studies containing synonyms were not absent. Publication time of all results ranged from 2007 to 2022 mechanically restricted by online library databases. And only peer-reviewed English articles were used for further screening to ensure high data quality.

This study conducted a PRISMA systematic review (Fig. 1) pattern, which was recommended for its effective structure and reasonable process [16]. Considering the limited technological requirements of VR devices, the data collection was operated completely online through a school library. The online library of the University of Edinburgh has access to more than one hundred databases in all ranges of fields with the latest collection.

In the first step, the resource type only displayed peer-reviewed records and was limited to English-language articles. No research preference was added in the first identification, and results showed in full subjects and non-targeted year of publication to avoid research biases. To facilitate the subsequent filtering and to analyze the data, all articles were sorted from newest to oldest and coded in the order of 1 to 169 when the original search results were obtained.

The flow chart then followed the inclusion and exclusion criteria in table 1 for the manual selection procedure in two steps. During rough reading, ten coded items on one page were in a screening group, followed by a review screening at the end of each page. The results of this step were collected by a check form. In a competent scientific article, the title specifies the main research question of the study and often contains keywords. Therefore, the initial reading mainly focused on titles and abstracts. Another round of title review of all 169 data was conducted after the first part of screening to ensure no misses and misreads. Only 14 articles reached the full-text reading part, and a rough summary form was filled according to the whole 14 articles. The final step identified and excluded records that

did not characterize social skills training as their primary research subjects, such as studies on basic life skills training and the evaluation of VR-based designs.

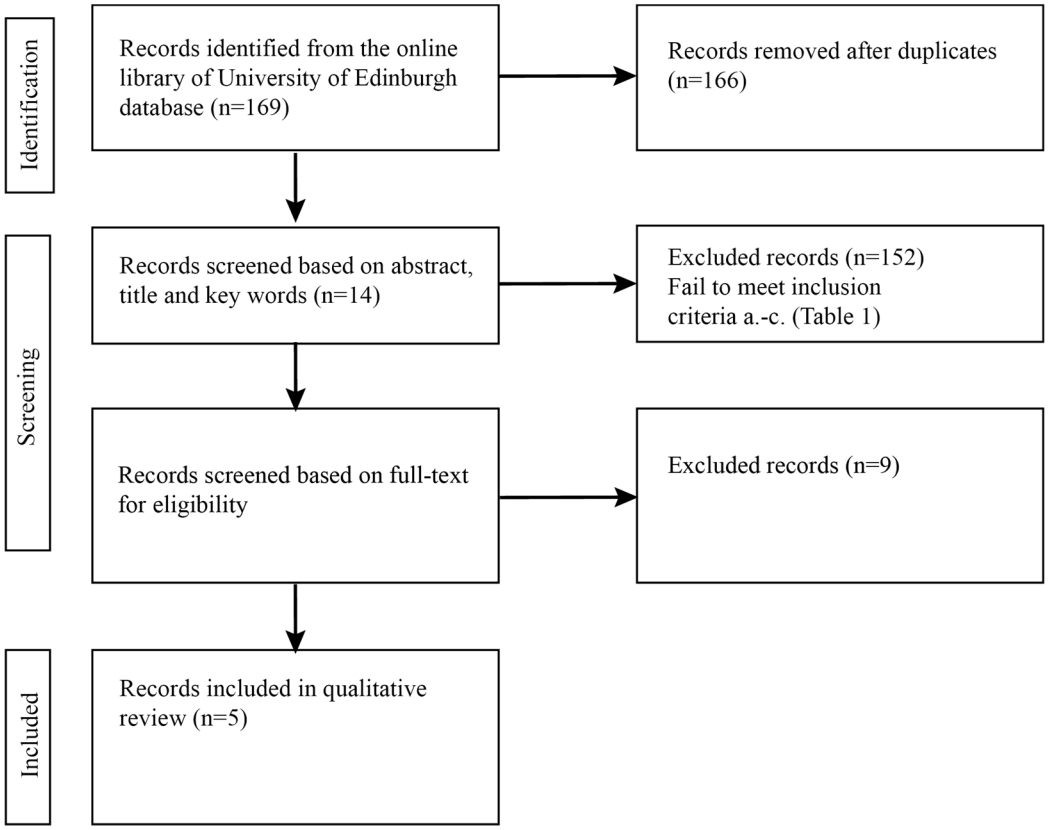


Fig. 1 A flow diagram of the article selection process

2.2 Inclusion and Exclusion Criteria

Table 1. Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
a. Participants were children and adolescents with ASD b. Virtual Reality was used in training c. Empirical study d. Social skills training	a. Participants over age 18 or with other diseases b. Not using VR in study c. Non-empirical study d. Using VR for other training purposes

In the screening part of the flow chart, most articles (n=152）were excluded before full-text reading as they failed to meet criteria a. to c. in table 1. This study targeted research that concentrated on under-18 children and teenagers with autistic sperm disorder. Records with participants older than this age or not specified were selected. Non-empirical studies like a literature review, systematic review and case analysis were excluded to avoid misinformation about the original data. Besides, VR should be an adaptable and practical method in impartial research instead of serving as the foundation of a system or education background in any of these articles. The most accurate and effective way of data selection was to read each of the 14 articles one-by-one in detail. Finally, five qualified records were selected and re-coded as A1 to A5 for further systematic review (table 2).

3. Results

A total of 276 participants, 235 males and 41 females were analyzed in the five selected articles. 151 participants received VR training in the Intervention Group (IG), and the rest 125 were in the Control/Comparative Group (CG). Two studies compared IG with CG in control studies, two simply analyzed the impact of the intervention in IG and the one remaining set a comparative group that

received intervention from a therapist. There was a clear gender distribution of children or youth in the IG group, with 85.43% of the subjects are male and 14.57% are female. The percentage of males in the control and comparative groups was 84.21% and 86.67%. The minimum number of participants in a study was 7, and the maximum was 117. According to the sources of candidates, two of the studies were in Hong Kong, two in America, and one in Italy. All studies specified the age range and genders of participants. The ages of participants ranged from 6 to 16 years old but were primarily 7 to 10 years old.

Table 2. Summary of included articles

Article	Code	Study Characteristics	Age/Groups(Sex)	Aim	Evaluation	Main Results
Ip, Horace H. S., et al 2022[13]	A1	Control study	Age:6-12 IG:(M 41, F 7) CG:(M 47, F 12)	Enhance effective expression and social reciprocity	RPM, PEP-3, Observation.	Significant improvements in both areas
Ke, Fengfeng, Jewoong Moon, and Zlatko Sokolikj 2022	A2	Multiple baselines design	Age:10-14 IG:(M 6, F 1) CG:-	Promote social skills performance	Screen recording and observation, SSQ, SCQ.	The level of social skills performance improved from baseline to intervention.
Frolli, A., et al. 2022	A3	Comparative study	Age:9-10 IG:(M 25, F 5) CG:(M 26, F 4)	Find the least acquisition time for the proposed emotion recognition tasks in the intervention	WISC-IV, ADOS 2-Module 3, DSM-5, SES.	Interventions in VR allow faster acquisition of emotional recognition
Ip, Horace H. S., et al. 2018	A4	Control study	Age:7-10 IG:(M 31, F 5) CG:(M 33, F 3)	Enhance emotional and social adaptation skills	RPM, CAST, ABAS-II, Faces Test, Eyes Test, PEP-3.	Significant improvement-s in emotional expression, regulation, and social interaction, but not emotion recognition.
Didehbani, Nyaz, et al 2016	A5	Intercommunication between children with ASD	Age：7-16 IG:(M 26, F 4) CG:-	Feasibility of VR-SCT to improve social skills	Triangles, (NEPSY-II)-Auditory Attention and Response Set, Ekman60.	VR-SCT effectively works in social cognitive intervention

RPM: The 60-item Raven's Progressive Matrices; PEP-3: Psychoeducational Profile, Third Edition; SSQ: Social Skills Questionnaire; SCQ: Social Communication Questionnaire; WISC-IV: Wechsler Intelligence Scale for Children; ADOS 2-Module 3: Autism Diagnostic Observation Schedule 2; DSM-5: Diagnostic Interview for the Evaluation of Psychopathological Disorders in Children and Adolescents; SES: Scale for the Evaluation of Socio-economic Status. RPM: Raven's Progressive Matrices; CAST: Childhood Autism Spectrum Test; ABAS-II: Adaptive Behavior Assessment System, Second Edition; NEPSY-II: The Developmental Neuropsychological

Assessment, Second Edition; Ekman60: Facial Expressions of Emotion Stimuli and Tests; IG: Intervention Group; CG: Control Group/Comparative group.

Studies included all screened participants for ASD level or IQ to ensure they were eligible in terms of understanding the content and instruction of the experiment. Studies A1 and A4 were carried out in mainstream elementary schools in the local area. None of the students who took part in the studies had cognitive deficits or belong to severe ASD patients. For A2, participants were required to have a medical diagnosis of autism and be able to communicate verbally, read, and write to complete the experiment on their own at home using a computer. Both A3 and A5 were carried out in controlled laboratory conditions. Subjects lower than 97 IQ scores were screened out in A3, while participants in A5 needed to have an IQ score that was average or higher than average. In terms of researchers and assistants, all the studies had at least one dominant instructor, and three in five included more than one experimenter. Particularly, the intervention process in A1 was guided by a researcher or a trained schoolteacher and observed by another researcher or untrained schoolteacher. A4, similarly, had one trainer and assistant. Both A3 and A5 invited clinicians to the intervention. A total of three trained facilitators in A2 engaged in manipulating virtual social characters in software.

A closer inspection of the text showed that the five articles share similarities as well as differences in many ways. In A1, the training of social skills included social norms and interaction skills, laying its focus on affective expression and social reciprocity. A3 went straight to emotion recognition, which is the basis of social communication. While the other three were more about general social skills in multiple contexts. Besides, three types of virtual reality systems were used to present scenarios in chosen studies: immersive VR systems which surround the user in a 360-degree virtual environment, including a VR helmet; desktop VR systems that display virtual reality on a computer monitor; and three-dimensional projection display technology which displays 3D objects onto a two-dimensional screen. Most research (80%) created highly interactive VR to imitate real-world communication and involve participants in a social interaction task. Background characters portrayed by researchers conversed with children in predetermined settings and promoted social tasks verbally when appropriate. Only A1 implemented a physically interactive intervention by employing a touch controller to track the head and hands of the participant in real time.

4. Discussion

The present study is aimed to analyze research focused on VR social skills training for children and adolescents with an autism spectrum disorder. A total of 5 published articles between 2016 and 2022 from the online library of the University of Edinburgh were selected and analyzed in this systematic review. As shown in Table 3, all studies demonstrated that VR training was effective with intervention groups.

Based on a large-scale empirical study, A1 showed that autistic students from a primary school can benefit from social skills training with VR headsets. Social skills performance increased among A2 participants, as well as an improved sense of self-identity and cognitive flexibility. A2 claimed that social skills may be learned more quickly in real-world settings and that 3D and contextual scenarios helped participants develop their skills more quickly. A3 also saw how these abilities were used in everyday life. The results of A4 demonstrated the feasibility of the development of emotional and social adaptation training based on virtual reality technology. A3 responded to queries raised by A4, proving that low-simulation VR devices were still valid in intervention. Furthermore, A5 shows that VR training remained effective even for participants with both ASD and ADHD.

Limitations of the selected studies can be found in VR devices, the gender ratio and the sample size of the participants. One problem is that the use of VR headsets or immersive VR caves is expensive and not conducive to long-term replication, making the intervention unsustainable. The call for large sample sizes can also be seen in almost all studies. Working with children with difficulties places greater demands on the ethics and design of experiments because, for example, they may resist wearing VR headsets and are more likely to withdraw midway. With the absolute

gender imbalance in individuals with autism, the phenomenon of male dominance among research participants was evident.

Kolb's experiential learning model was used in A1 to develop five sections and eight VR learning scenarios to maximize the effectiveness of VR training. It gave strong theoretical funding and future inspiration for the training design and the design could have a significant impact on participants' learning outcomes. An innovative way of using VR in peer interaction can be found in A5. Researchers proved that VR could facilitate remote peer interaction when peers were physically separated but engaging in a shared task or activity. This can also be an appealing method for future study to socialize with ASD individuals who may not be comfortable being physically close to others but can also learn to collaborate.

5. Conclusion

The study adopted the PRISMA systematic review pattern in screening 215 articles in the online database of the University of Edinburgh and selected 5 qualified records for a quantitative review. According to the study analyzed, VR was both effective and feasible for social skills interventions with significant data characteristics. Overall, VR technology is a promising medium for providing entertaining and stimulating training programs for the ASD population. The current evidence indicates that VR interventions can be used to train children and adolescents with ASD in a variety of social scenarios. By wearing helmets, operating computer avatars, viewing 3D projections and engaging in immersive VR-SCT, participants can learn emotional recognition, social norms and handle complex conflict situations in the virtual world. All these strategies assist children and youth with ASD to better adapt to society and build social relationships with others. The study was limited by the small sample size of the reviewed works. In addition, there was not enough controlled study to determine the superiority of VR intervention compared with traditional methods. It is also likely that some of the conclusions drawn across genders are limited by the presence of more than three-quarters of male participants. Thus, it would be interesting to conduct a study with a larger sample size and on whether girls with ASD respond differently to social interactions in the future.

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