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Applications of Virtual Reality for Autism Inclusion. A review Aplicaciones de la realidad virtual para la inclusión del autismo. Una revisión

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Abstract. Children with Autism Spectrum Disorder present several difficulties in social interaction, communication obstacles and restricted and repeated behaviors. Social connection with others is typically challenging for them, and they are frequently unsure of how to react to other people's emotions, facial expressions, and movements of their body, and especially of how to respond to various social circumstances. Recent review studies regarding VR for children with ASD have found that most of the relevant interventions aimed at improving social and emotional skills, as well as common activities of everyday life. In this work, we are going to present studies of the most current applications of VR technologies to the education of students with ASD with the aim to gain an updated overview of the use of VR in this field. A thorough search was conducted in Scopus and Pubmed databases, as well as through Google Scholar, using the keywords 'Virtual Reality', 'Autism Spectrum Disorder', 'application', 'intervention', 'students', 'education' and their combinations, for the period 2015–2021. Our search was limited to studies presented in English. A total of eight (8) studies met the inclusion criteria. The majority of the results we described were positive and quite encouraging, as the deficits in these domains are life-determining for individuals with ASD. Given that many barriers (e.g., regarding cost and comfort issues) to using the VR technologies have been overcome, more effort should be put to the production of wider and more robust experimental research in the specific field, as well as to the testing of generalizability issues in real life.

Keywords: Virtual Reality, Autism Spectrum Disorder, Application, Intervention.

Resumen. Los niños con Trastorno del Espectro Autista presentan varias dificultades en la interacción social, obstáculos en la comunicación y comportamientos restringidos y repetitivos. La conexión social con los demás suele ser un reto para ellos, y con frecuencia no saben cómo reaccionar ante las emociones, las expresiones faciales y los movimientos del cuerpo de otras personas, y sobre todo cómo responder a diversas circunstancias sociales. Los estudios de revisión recientes relativos a la RV para niños con TEA han encontrado que la mayoría de las intervenciones relevantes se dirigen a mejorar las habilidades sociales y emocionales, así como las actividades comunes de la vida diaria. En este trabajo, vamos a presentar estudios sobre las aplicaciones más actuales de las tecnologías de RV a la educación de alumnos con TEA con el objetivo de obtener una visión actualizada del uso de la RV en este campo. Se realizó una búsqueda exhaustiva en las bases de datos Scopus y Pubmed, así como a través de Google Scholar, utilizando las palabras clave «Realidad Virtual», «Trastorno del Espectro Autista», «aplicación», «intervención», «estudiantes», «educación» y sus combinaciones, para el periodo 2015-2021. Nuestra búsqueda se limitó a los estudios presentados en inglés. La mayoría de los resultados que describimos fueron positivos y bastante alentadores, ya que los déficits en estos dominios son determinantes para la vida de los individuos con TEA. Dado que se han superado muchas barreras (por ejemplo, en relación con el coste y los problemas de comodidad) para el uso de las tecnologías de RV, se debería poner más empeño en la producción de una investigación experimental más amplia y sólida en el campo específico, así como en la comprobación de los problemas de generalización en la vida real.

Palabras clave: Realidad Virtual, Trastorno del Espectro Autista, Aplicación, Intervención.

Introduction

Children with Autism Spectrum Disorder (ASD) present several difficulties in social interaction, communication obstacles and restricted and repeated behaviors (American Psychiatric Association, 2013; Tsai, Lee & Chen, 2020). Social connection with others is typically challenging for them, and they are frequently

unsure of how to react to other people's emotions, facial expressions, and movements of their body, and especially of how to respond to various social circumstances (Bölte & Hallmayer, 2011; Hillier, Fish, Cloppert & Beversdorf, 2007; Tsai, Lee & Chen, 2020). They usually prefer to avoid human faces and find it difficult to grasp why facial characteristics are changing. As a result, their inability to interpret emotions in the human face limits their capacity to connect with others (Chaidi & Drigas, 2020). In recent years, numerous technologies are being tested for reinforcing and supporting learning and behavior of children who face

the above-mentioned difficulties (Papathomas & Goldschmidt, 2017).

The increasing number of research publications regarding the effectiveness of Virtual Reality (VR) technologies for children and adolescents with ASD in the field of education indicates that VR applications are gaining the attention as promising intervention tools for students with ASD (Lorenzo, Lorenzo-Lledó, Lledó & Pérez-Vázquez, 2020; Papoutsi, Drigas & Skianis, 2021; Drigas et al. 2005). Recent review studies regarding VR for children with ASD have found that most of the relevant interventions aimed at improving social and emotional skills, as well as common activities of everyday life (Lorenzo, Lledó, Arráez-Vera & Lorenzo-Lledó, 2019; Mesa-Gresa, Gil-Gómez, Lozano-Qulis & Gil-Gómez, 2018). The review of Lorenzo et al. (2019) focused on immersive VR applications for ASD students and concluded that despite the methodological problems of the studies, the structuring and realism accomplished by these technologies helped students to improve their skills. Bradley and Newbutt (2018) also identified promising evidence about the potential of VR head-mounted displays for the education of children on the autistic spectrum.

Virtual Reality Learning Environments (VRLE), with defined educational aims and design, meet the standards for usage as teaching and learning environments for children with ASD. Such virtual contexts can provide controllable and individualized conditions, with manageable social and sensory inputs, so that students can practice several interactions and skills within safe and predictable spaces (Bradley & Newbutt, 2018). Furthermore, with the decreasing costs and the more comfortable formats of VR technologies in recent years, their wider usage is becoming more viable (Ip & Li, 2015; Moore, McGrath & Thorpe, 2000; Ip, Wong, Chan, Byrne, Li, Yuan, Lau & Wong, 2016). In this work, we are going to present studies of the most current applications of VR technologies to the education of students with ASD with the aim to gain an updated overview of the use of VR in this field.

Technology and in particular Artificial Intelligence systems, are being researched in connection to the potential benefits it may have on the evaluation of autism (Anagnostopoulou et al., 2020; Drigas et al., 2013). Furthermore, Information and Communication Technologies (ICTs), as a method, resource, tool, technique, or instrument that promotes and advances information, communication, and knowledge, have paved way for assisting children with ASD after they

are diagnosed (Fernández Batanero, Montenegro Rueda, Fernández Cerero, & Tadeu, 2021; Stathopoulou, Karabatzaki, Tsiros, Katsantoni, & Drigas, 2019). These technologies enable the development of fully autism-appropriate teaching models and provide therapists and instructors with a variety of tools to work with. The excitement around the use of new technology might be attributed to children with ASD's desire for such items. For the majority of autistic teenagers, screen-based technology is a primary and preferred discretionary activity (Stathopoulou et al., 2019). Other technologies that are promising in supporting children with ASD, include the mobile applications, which together with their accompanying features, such as the use of 3D animation, offer a comfortable and cost-effective option for children with ASD and their families. The adaptability, customization, accessibility, and readiness of these technologies have created new options for improving and raising the quality of support to alleviate inadequacies in children with ASD (Karabatzaki et al., 2018; Papoutsi et al., 2018; Drigas et al., 2016).

Another potential technology is virtual reality hypnosis, which employs a head-mounted display to create a controlled virtual world adaptable to various hypnotherapeutic treatments. Because it replaces many stimuli that patients struggle to visualize via verbal cueing, it can be useful for those with attention deficits and mental imagery disorders. Hypnotherapy combined with biofeedback can be used to help people with ASD develop self-regulation skills and adaptive behaviors (Drigas, Mitsea, & Skianis, 2021). Also, neuro-linguistic programming (NLP), which can be combined with VR environments, provides influencing techniques for people with special educational needs to quickly engage in those states of mind that reduce implicit prejudice and promote positive behaviors and academic accomplishment (Drigas, Mitsea, & Skianis, 2022).

Method

A thorough search from three (3) reviewers at the end of the year 2021 was conducted in Scopus and Pubmed databases, as well as through Google Scholar, using the keywords 'Virtual Reality', 'Autism Spectrum Disorder', 'application', 'intervention', 'students', 'education' and their combinations, for the period 2015–2021. Our search was limited to studies presented in English. The following criteria for the selection of studies were used: (i) the study population consisted of children or/and adolescents with ASD; (ii) the study used at least

one kind of evaluation procedure; (iii) the application focused on school- related procedures, situations and settings, as well as relevant skills (that is, interventions for daily living or other skills concerning, e.g., air travelling training, supermarket shopping, etc., were not included). A total of eight (8) studies met the inclusion criteria (Figure 1).

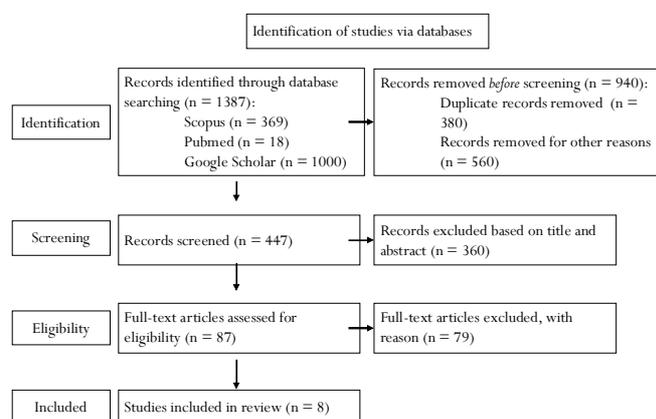


Figure 1. Flow Chart of the Selected Articles

Results

The presentation of the studies includes (a) the aims, (b) the VR technologies/techniques used and (c) the evaluation results.

Parsons's (2015) small-scale study illustrates an innovative collaborative first-person virtual environment (CVE) game for children with ASD, termed Block Challenge, with the aim to encourage cooperation and mutuality in behavior and communication. The CVE used a conceptual framework of design based on the learner-centered 3T (Theory, Technologies and Thoughts) model, for developing autism-related instructional technologies, that could ease the learning process of students with ASD (Parsons & Cobb, 2014). Block Challenge ran on laptops and the participants used the mouse to navigate. Each user had to cooperate with another user via a headset and comprehend his/her point of view in order to complete the game. Participants were fourteen (14) students from England, six (6) of which were ten (10) to thirteen (13) years old with ASD and the rest were seven (7) to nine (9) years old with Typical Development (TD). The study included three (3) sessions of thirty (30) minutes each and lasted two (2) weeks. During the training, participants were divided into pairs of children with ASD and pairs of children with TD. The pairs of children with ASD made constant efforts, needed much information from their facilitators and made many

moves to complete the tasks of the game. Their training resulted in mutual, but less efficient and not as focused communication as the one of the pairs of children with TD. Although the findings seemed promising for the effectiveness of Block Challenge, the small number of participants did not allow the generalization of the study's outcomes.

In the single-case study of Cheng, Cheng-Li and Chung-Sung (2015), an immersive Three- Dimensional Social Understanding (3D-SU) system was used, in order to research if it would help children with ASD enhance their social comprehension and abilities. The system used a virtual display that was mounted to the head of each participant and generated a 3D environment which appeared to surround the user. Such a system may aid in the recovery of the capacity to maintain focus, a problem that is usually present in children with ASD, as it decreases the distractions. A classroom and a bus stop were chosen as the social situations for the participants' training. The subjects of the study were three (3) boys from ten (10) to thirteen (13) years old with an ASD diagnosis. The duration of the experiment was six (6) weeks, which included three (3) sessions for each of the three (3) phases, with them being baseline, intervention and maintenance. The results of the study showed improvement of all participants in non-verbal communication, initiation of social situations and social awareness, which indicate that the system was efficacious.

In their article, Bekele, Wade, Bian, Fan, Swanson, Warren and Sarkar (2016), explored the use of an adaptive multimodal social interaction platform based on virtual reality for children with ASD that can distinguish their pattern of processing and mental condition. The platform was able to detect the user's eye movement and peripheral psychophysiological and electroencephalography (EEG) signals. A school's cafeteria is present as the virtual environment and the users were trained in order to be able to distinguish emotions through the recognition of facial expressions. In the study participated twelve (12) children from thirteen (13) to seventeen (17) years old with clinically diagnosed ASD, half of which were utilized as a gaze group and half as a control group. Preliminary results of this study showed that the platform is promising for training children with ASD, in order for them to function better in social situations.

Lorenzo, Lledó, Pomares and Roig (2016) presented in their research an immersive VR system, with the

aim of developing and improving the emotional skills of primary school students with ASD. In this system, a 3D virtual world was presented to each user, offering a controlled and safe representation of real-world situations, in order to enhance the user's emotional skills. A robot with a built-in camera recorded the user's emotional expressions and posture, when interacting with the virtual environment, in order to determine his/her emotional state and whether it is appropriate for each social situation represented. Four (4) out of the six (6) basic facial expressions were detected by the software used: anger, joy, sadness and surprise. In this study forty (40) students with ASD, aged seven (7) to twelve (12) years old participated, which were randomly divided into half and assigned to the experimental and control phase. The results of the research showed that the users' emotional reactions improved, not only during the sessions, but also in their real school environment, indicating that the skills acquired through the application of the virtual reality system can be transferred to real-world social situations.

In the study of Ip, Wong, Chan, Byrne, Li, Yuan, Lau and Wong (2016), a Virtual Reality-enabled system was used, in order to help students with clinical or suspected diagnosis of ASD, in Hong Kong, socially adapt via training in an inclusive, genuine, secure and manageable learning environment. The aim of the VR environment presented is to help students with ASD be able to recognize their inner feelings, express their thoughts, cope with difficult social everyday situations and develop compassion. The system comprises six (6) VR educational scenarios, which are offered through a VR environment which resembles an immersive Cave Automatic Virtual Environment (CAVE) with four (4) screens (one for each side) using head tracking for correcting the user's perspective. Participants of the pilot phase of the study were 20 primary school students from six (6) to nine (9) years old with diagnosis or suspected diagnosis of ASD and an IQ more than seventy (70), minus one (1) drop out. Participants of the study's trial phase were thirty-three (33) children from six (6) to eleven (11) years of age and training's duration was twenty-eight (28) sessions of one (1) hour, divided into fourteen (14) weeks. After the training sessions, preliminary findings demonstrate that participants improved sufficiently in the perception and expression of emotions, as well as in the reciprocity in social situations. Results may also be generalized, as the researchers observed and assessed the participants in real world classrooms as well.

In their later study, Ip, Wong, Chan, Byrne, Li, Yuan,

Lau and Wong (2018), an immersive CAVE virtual reality environment is assessed, using the same six (6) VR educational scenarios, with the aim of ameliorating the socio-emotional adaptation of children with ASD, in the school setting. This time, ninety-four (94) children with ASD diagnosis, from six (6) to twelve (12) years old, took part in the twenty-eight (28) sessions for fourteen (14) weeks. Results showed amelioration of the preliminary outcomes from the experiment's implementation, specifically concerning participants' expression and control of emotions and reciprocity in social situations.

Herrero and Lorenzo (2019) also developed an innovative Immersive VR educational intervention for high-functioning ASD students that aimed to address emotional problems as well as verbal and social communication difficulties. They designed a head mounted display system that recreates a realistic, familiar, and flexible learning environment of a school context, where several socialization and communication circumstances can occur. Thus, children can interact with avatars in various ways and in different situations and practice their emotional and social competences in a safe, controlled and non-distracting space. Specifically, the VR application uses two scenes of the same school environment: the classroom and the school garden. The first setting focuses on the improvement of verbal and non-verbal communication skills, Theory of Mind and joint attention, while the second setting works on emotional regulation and empathy in the light of equity, respect, inclusion and avoidance of violence. To evaluate the effectiveness of the intervention, the researchers implemented an experimental design, with 14 students with ASD between 8 and 15 years old who were randomly assigned to either the intervention group (7 students) or the control group (7 students). The assessment results indicated an overall positive impact for the first group, with the greatest improvements being observed in the aspects of social and emotional reciprocity and inflexibility to changes.

The goal of the study of Tsai, Lee and Chen (2020), was to help children with ASD perceive the six (6) basic emotions more accurately and teach them social skills, by employing a both first- and third-person perspective role-playing game approach, which utilized immersive 3D images of virtual reality characters. When it comes to acquiring new knowledge and communicating with people, first-person role-playing is frequently utilized, in order to help children with ASD improve their interpersonal skills, despite its disadvantage of not

allowing users to see themselves in a variety of social circumstances. Children benefit from being able to watch themselves from a third-person viewpoint, as they may utilize this knowledge to better comprehend and reproduce what they see, improving their socio-emotional consciousness and reciprocity of themselves. This is why the role-playing game of this study gave the ability to the user to switch between the first- and third-person's viewpoints. Role-playing games are, also, a great method for parents and educators to engage with children with ASD at home or at a school setting. The first part of this research used standard emotion recognition figure cards and the second comprised a participant entering a 3D Cave Automatic Virtual Environment (CAVE), which included three screens, one in the front and two on the sides of the user, in order to project the interactive games. The training intervention lasted five (5) weeks, with the participation of three (3) children with ASD, aged seven (7) to nine (9) years old. Results showed that their role-play performance improved significantly throughout the intervention period and remained much better during the maintenance period.

Conclusions

In line with previous relevant literature (Lorenzo, Lledó, Arráez-Vera & Lorenzo-Lledó, 2019; Mesa-Gresa, Gil-Gómez, Lozano-Quilis & Gil-Gómez, 2018), the VR application studies included in the present overview targeted the improvement of emotional skills and competences related to social communication and social interaction within the school context, which according to Drigas & Pappas (2017), are ultimately helpful to reach higher levels of intelligence and consciousness. The majority of the results that were described were positive and quite encouraging, as the deficits in these domains are life-determining for individuals with ASD (American Psychiatric Association, 2013).

Most studies used the Immersive VR type, possibly due to the greater level of realism, interaction and overall immersion achieved by this kind of VR technology (Herrero & Lorenzo, 2019). Some of the studies that were analysed used high-resolution projection on large screens technology that is applied to the goals of VR, that were viewer-centered and gave the impression to the user that he/she is surrounded by a 3D world, with which he/she could interact. Other studies used head-mounted display technology, consisting

of two small monitors connected to a PC with built-in head position sensor, in order to adjust viewers direction to the virtual environment. Only two (2) of the studies used a computer to present the VR environment to the user who interacted with it via the keyboard and/or the mouse (Cheng, Huang & Yang, 2015; Cruz-Neira, Sandin & DeFanti, 1993).

Overall, the current usage of VR educational environments - especially the immersive ones - that aims to support ASD students at the core difficulties occurring from the specific disorder, seems promising. Given that many barriers (e.g., regarding cost and comfort issues) to using the VR technologies have been overcome (Bradley & Newbutt, 2018), more effort should be put to the production of wider and more robust experimental research in the specific field, as well as to the testing of generalizability issues in real life.

Some limitations of the current article include the included articles where limited to the most recent ones (2015-2021) and their population consisted of just children or/and adolescents with ASD. A more in-depth research with broader criteria, could potentially lead to more specific results about the use of VR from individuals with ASD and the improvement of emotional skills and competences related to social communication and social interaction within the school context.

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