



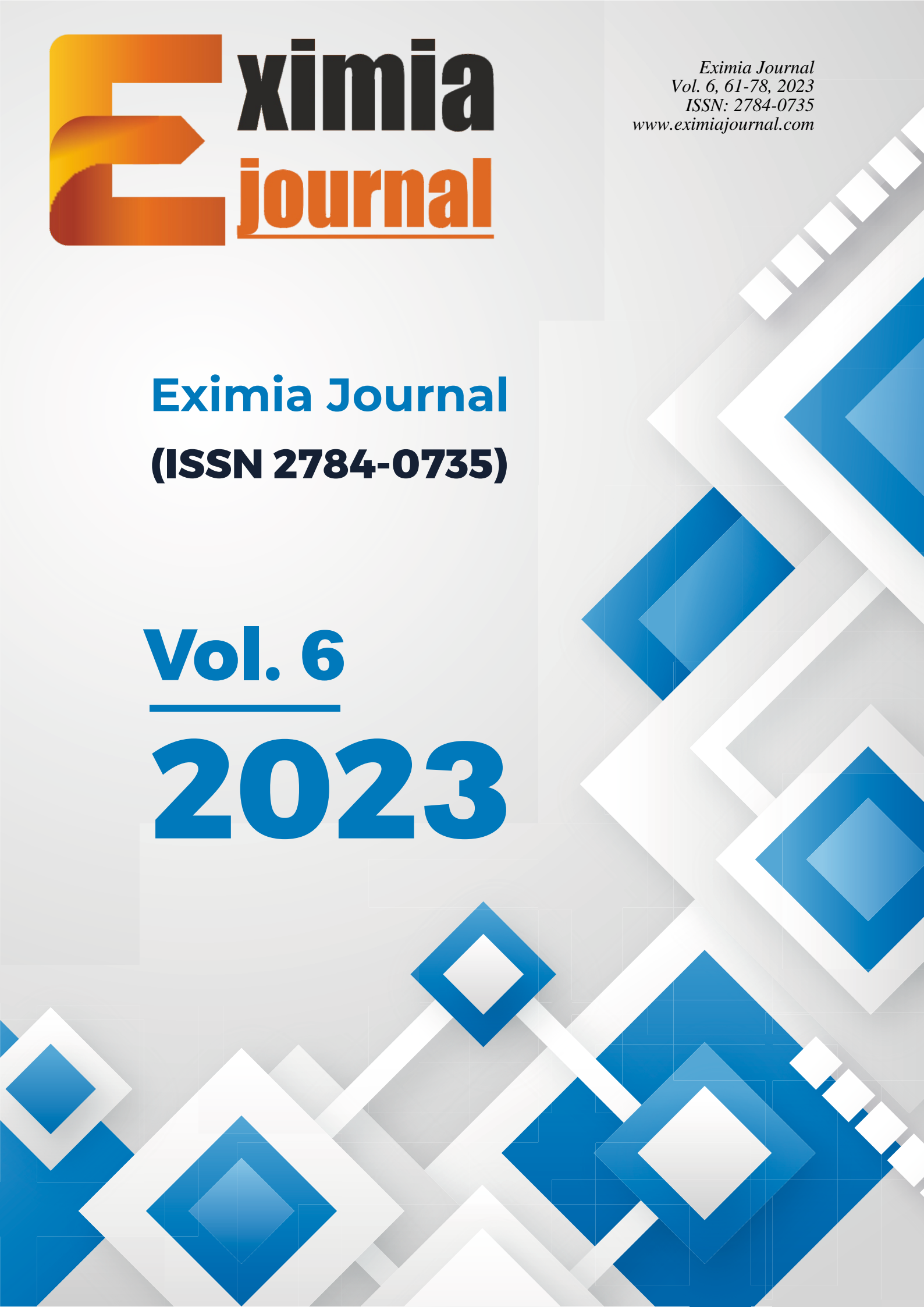
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## **Digital Technologies and Virtual reality (VR) as therapeutic intervention for stress reduction in ASD**

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**Abstract:** A promising tool has recently appeared in many areas called virtual reality. Virtual reality (VR) is real-world simulation based on computer graphics and can be used as an educational and therapeutic tool by educators and therapists to provide children with a safe learning environment. Below are studies to demonstrate the effectiveness of virtual reality in reducing stress in individuals with autism and promoting the development of emotional skills.

**Keywords:** Virtual reality, virtual environment, stress, emotional intelligence, ASD

### **1. Introduction**

This literature review focuses on the use of virtual reality which now complements and supports the work of therapists and teachers. The use of digital technology and specifically VR virtual reality is a particularly important innovative scientific event because it is able to help children develop skills and acquire knowledge that will change the quality of life and also contribute to the management of high levels of stress, helping to eliminate it. An appropriately designed virtual reality tool can be effective for stress management in children with ASD through the creation of a specially adapted virtual environment that provides appropriate stimuli to individuals with autism and is able to integrate them into a state of relaxation and calmness through the secretion of specific anti-stress hormones. Still, the use of virtual reality VR, can be considered particularly effective in empowering children with ASD on a learning, social and communicative level while promoting the development of mindfulness and the cultivation of their emotional intelligence.

### **2. Virtual reality (VR) as an intervention tool**

Virtual reality consists of a video camera and software to track movement in a single plane, without the need to place markers - sensors in specific body positions of the person with autism - user. The user's image is embedded in a simulated environment in order to encourage

interaction with animations and graphics in a natural way. Although this technology has been known for twenty-five years, it has only been applied as an intervention method for people with ASD in the last five years. The study by Weiss and colleagues (2014), aims to describe how this technology works, review its elements in other virtual reality platforms, and provide an overview of some of the major studies that have evaluated the use of virtual reality technologies as an intervention tool for individuals with autism (Weissetal., 2004).

Through this research, the feasibility, utility and flexibility that characterize virtual reality using video cameras for motion tracking is clearly established. Undoubtedly, the technology is a useful tool that can be incorporated into interventions designed and implemented for individuals with autism spectrum disorder. Virtual reality is a promising technology for achieving a multitude of therapeutic goals, including cognitive and motor functions. The general advantages of virtual reality for the education and treatment of individuals with ASD, as summarized above, provide compelling arguments for the inclusion of this type of technology in the tools used with individuals with ASD in and out of clinical settings (Weissetal., 2004).

Weissreports that market demand, user interest and improvements in technology have led to the availability of many different virtual reality video capture platforms. There is no doubt, whether these platforms are useful intervention tools for the rehabilitation of patients with neurological and musculoskeletal disorders, can be easily acquired, in any setting, clinical or home, and encourage regular and intensive treatment in these individuals(Weissetal., 2004).

In the study by Yang and colleagues (2018), the effectiveness of the intervention implemented was based on systematic observation of the participants' target behaviour. This study aimed to determine the neural and behavioural changes of adults with high-functioning autism who received a behavioural intervention with embedded virtual reality for a period of five weeks. This study utilized a dual mode of assessment, through target behaviour and through neurological activity. Neurological activity was assessed using an MRI scanner, specifically by measurements in the BOLD hematological response (Yangetal., 2018).

Three significant changes in brain neurological activity were identified from this test. First, the right posterior superior temporal groove, a node for social-cognitive processing, showed increased brain activation to social versus non-social stimuli in subjects who have "mastered" theory of mind. Second, the left inferior frontal gyrus, an area for social-emotional processing,

in which there appeared to be reduced activation of emotions versus non-social stimuli. Finally, the left superior parietal lobe, a brain area for visual attention, appeared to have limited activation to non-social stimuli, relative to social stimuli, in all participants (Yangetal., 2018).

The subjects in the present study were 17 young adults who had received a diagnosis of high-functioning autism. Their intelligence was measured using the abbreviated Wechsler Intelligence Scale (WAIS) (Wechsler, 1999, 2011). All participants met the DSM-5 diagnostic criteria for ASD, based on the assessment they received from independent and reliable evaluators (e.g., child psychiatrists and clinical psychologists) (Yangetal., 2018).

Although, the above study has many limitations, it is the first to examine the effect of a treatment protocol utilizing VR-SCT technology on the brain activity of adults with ASD. From the findings that were extracted, it appears that individuals with ASD may be able to benefit from even short-term intervention focused on social interaction in young adulthood. These types of interventions may not only improve social cognitive skills at a critical stage when adults with ASD need to develop social skills that support independence, but also strengthen underlying brain networks to support higher social functioning (Yangetal., 2018).

At the same time, it has been found that people with DMD have made significant progress from implementing rigorous physical activity, however, it is often difficult to motivate them to exercise due to their sedentary lifestyle. To create motivation, the researchers in the following study developed Astrojumper, a stereoscopic exergame (exercise + game) virtual reality model designed to fit the needs of children with ASD. For this model, the researchers created a virtual environment for which they used electromagnetic trackers containing 3 facets of the CAVE (Cave automatic virtual environment) system to design. The CAVE virtual environment, in the form of a room, was used by the researchers to present visual stimuli to the user, who had to use physical movements to avoid collisions and to score points in the virtual room. Astrojumper can be used to motivate people with ASD to engage in physical activity, but also to evaluate the different ways in which people with and without ASD interact with a physical exercise tool (Finkelstein et al., 2010).

The preliminary testing of the Astrojumper game had positive results and the researchers sought to thoroughly evaluate the effectiveness of this system in children with and without

ASD. During the piloting of the game, no errors were identified and it was ensured that the difficulty level of the Astrojumper was appropriate for the participants. Eight neurotypical subjects participated in the preliminary trial and completed a questionnaire after the end of the experimental procedure. Through the participants' responses to the questions on the questionnaire, it appeared that they found the game fun and ideal for motivating engagement in physical activity (Finkelstein et al., 2010).

In the long term, the researchers hope to conduct an evaluation regarding whether there is a significant difference between neurotypical and ASD individuals regarding exercise and the implementation of different interventions in the form of play. The Astrojumper, as a rehabilitation tool for people with PD, contains appropriate activities that promote cognitive ability and motor activity (Finkelstein et al., 2010).

In general, people with ASD can benefit from exergames, but there is not enough data on how they interact and how they should be designed. From piloting the familiar game with typically developing individuals, Astrojumper appeared to be an engaging game in which participants really enjoyed using it. Although the findings from the preliminary research are certainly promising, they do not help us to predict how individuals with ASD will respond to the stimuli provided by Astrojumper. A thorough evaluation is needed to design and adapt the applications of this game to the preferences and capabilities of the individuals (Finkelstein et al., 2010).

Finally, noteworthy are the findings of a literature review that explores how virtual reality systems are or have been used as therapeutic methods to treat the primary impairments caused by three disorders: attention deficit disorder with or without hyperactivity (ADHD), autism spectrum disorder (ASD) and cerebral palsy. According to the findings of the review, it is noted that virtual reality visualisation systems can be divided into three subcategories depending on the type of interaction achieved between the user and the computer. The categories are as follows: feedback-focused interaction that enables the user to understand everything he/she gained from the process, interaction based on user gestures, and interaction based on the user's tactile contact with avatars (Wang & Reid., 2011).

As mentioned in this review, the effectiveness of a virtual reality intervention is examined from different perspectives: the cost-benefit perspective of the treatment, the treatment effectiveness perspective, and the social acceptance perspective of the treatment. Initially, although

sophisticated and adapted technologies promise to improve the quality of human interaction with computer reality, their benefits are mitigated by their rather high costs and by the lack of knowledge about their proper use. Subsequently, the goals regarding the use of virtual reality as a rehabilitation tool should be reviewed (Wang&Reid., 2011).

The review carried out in the context of the research analysed, focused on the rehabilitation of primary behavioral deficits in children with cerebral palsy, ASD and PD. At this point it should be mentioned that all three disorders have a direct correlation with cognitive deficits. From the conclusions of the literature review, it was found that, through the use of virtual reality, it is possible to holistically address both the cognitive and behavioural deficits associated with these three disorders. With regard to the degree of validity of virtual reality programmes, it is an aspect of the relevant issue that remains unresolved. In general, the possibility of using virtual reality in children with disabilities is intended to stimulate interest and discussion for continued use of virtual technology in the field of pediatric neurorehabilitation (Wang&Reid., 2011).

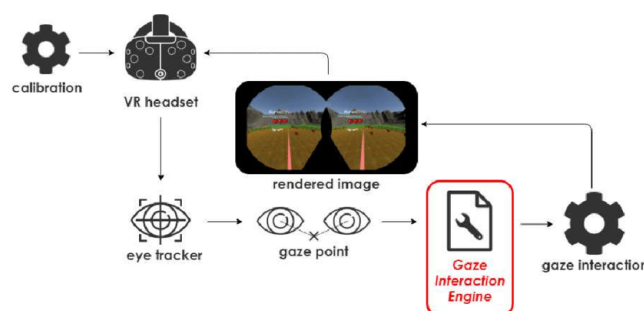


Image: VR Virtual Environment Play in a natural environment

### 3. Virtual reality and stress reduction in people with ASD

In the international literature, research has already been conducted that aims to use virtual reality in relation to reducing anxiety in people with ASD. Specifically, the research by White and colleagues (2017), aims to investigate the effectiveness of applying psychosocial and computer-assisted intervention to university students diagnosed with ASD. The main reason that prompted the researchers to conduct this research is related to the fact that to date, very little research has been conducted to investigate interventions that act supportively on the intimate group of individuals. This study examines data from a pilot trial of two new

intervention programmes implemented with students with ASD. Based on the results, psychosocial and computer-assisted interventions for these individuals appear to be effective and efficient (Whiteetal., 2017). More specifically, the study was approved by the university's ethics committee and the random sampling method was used to ensure that the results were valid. Students were recruited through the university's disability services office and were informed via email and relevant leaflets were distributed. Inclusion criteria required participants to 1) be at least 18 years of age, 2) be enrolled full-time in classes and have a good academic record so that participation in the program would not adversely affect their academic performance, 3) meet diagnostic criteria for autism spectrum disorder, and 4) have no other psychopathology warranting more intensive or acute treatment. Students enrolled at the beginning of the fall semester and completed final evaluations approximately 3.5 months later, toward the end of the same semester (Whiteetal., 2017).

All participants responded to a ten-point scale measuring their level of satisfaction with the program. Two types of interventions were designed as part of the intrinsic research, aimed at helping students with ASD to respond to social situations and manage anxiety. The first intervention was conducted using the Cooperative Learning Scale (CLS) and the second using data obtained from the Brain-computer interface (BCI). According to the responses provided, participants in the CLS intervention expressed somewhat greater satisfaction with the program than participants in the BCI intervention. Qualitative feedback indicated that CLS participants found the following aspects of the program most useful: weekly social coaching to monitor their progress, opportunities for social interaction, and the development of their communication skills. In response to the question of what was least helpful, CLS participants indicated that they would have liked more time for stress and anxiety management, less time for assessment and more individualization of the issues addressed in treatment (Whiteetal., 2017).

Due to the small sample size, the researchers were unable to draw firm conclusions about the effectiveness of any of the programs. Another limitation was that the post-intervention assessments were done at the end of the semester during final exams, while the pre-intervention assessments were done either before the semester began or during the first week of classes. These time points are periods of relatively high and low stress, respectively, and it is

understandable that this difference in stress levels may have influenced the survey results as a parasitic variable. (Whiteetal., 2017).

Oing and Prescott (2018) then sought to study alternative treatments in reducing anxiety in people with anxiety disorders. Specifically, previous studies have been conducted to address stress that have applied virtual reality technologies. Through virtual reality, it is possible to create different environments and scenarios and gives therapists the ability to have control over variables that would otherwise be difficult to control in a physical environment (Oing&Prescott, 2018). The aim of this research was to determine the effectiveness of virtual reality-based intervention, as well as outlining how modern virtual reality systems should address the shortcomings of legacy virtual reality systems. In order to effectively explore the aforementioned objective, a systematic search for any virtual reality-related peer-reviewed articles that would focus on the treatment and assessment of anxiety-based disorders took place. Articles were published before August 31, 2017, in the ProQuestCentral, PsycINFO, and PsycARTICLES databases (Oing&Prescott, 2018); a total of 49 studies met the inclusion criteria from an initial pool of 2419 studies. These studies were a combination of case studies that focused exclusively on VRET (VirtualRealityExposureTherapy), experimental studies that compared the effectiveness of VRET with the principles of CBT (e.g., in vivo exposure, imaginal exposure), and studies that evaluated the utility of VR technology as a diagnostic tool. The majority of studies reported positive findings in favour of VRET despite the limitations of VR technology (Oing&Prescott, 2018).

In addition to the aforementioned studies, research has also been conducted that discusses alternative treatments to reduce stress, but in previous research, it has been documented that criminal violence is associated with mental health problems such as depression and substance abuse. Furthermore, in terms of victims of violence, two of the most significant disorders they experience as the recipients of criminal violence are Post Traumatic Stress Disorder (PTSD) and Acute Stress Disorder (ASD) (Foa, Keane, etal., 2000). Designing treatments that involve the use of virtual reality and tailoring them to the needs of victims of violence could be a promising therapeutic intervention to address the very serious disorders that victims experience. The research ofCárdenas - López and colleagues (2014), responds to this need by investigating the effectiveness of a therapeutic intervention that utilizes virtual reality

methodology in individuals with Post Traumatic Stress Disorder (PTSD) and Acute Stress Disorder (ASD) (Cárdenas - López., 2014). The clinical sample was formed from 9 participants in Mexico City, 6 participants with a diagnosis of Post-Traumatic Stress Disorder (PTSD) and 3 participants with a diagnosis of ASD, aged 18 to 65 years old. All participants gave informed consent to participate. The treatment was administered in 90-minute sessions held once a week and during which three virtual scenarios for exposure therapy for people with PTSD were used (Cárdenas - López., 2014). The study showed that there was an improvement in measures of stress, anxiety and depression in both groups of participating subjects, which confirms the clinical effectiveness of this technique for the treatment of stress-related disorders (Cárdenas - López., 2014). Therefore, virtual reality can be part of educational transformation, and bring changes not only in the daily life of society but also in the cognitive ability of people, especially people with ASD, equipping them with the ability to see objects, places and situations that they cannot come into contact with in reality (Drigas, et al., 2022).

#### **4. Types of VR environment**

In the following study, Wang et al. (2019), examined the effectiveness of different types of forest environments for forest therapy to combat anxiety. Seven different forest environments found in Beijing were used as independent variables and incorporated into a virtual environment software. Stress/anxiety levels were used as the dependent variable and blood pressure, heart rate, salivary amylase were used as physiological and psychological indicators (Wangetal., 2019). During the experiment, 96 subjects were randomly assigned to each type of environment. Of the seven forest environments, there was only one type of forest resting environment. From the results of the procedure, it was found that all seven different types of forest rest environments can produce stress/anxiety relief effects to some extent. In particular, it was observed that all the different types of forest rest environments had different effects in terms of stress/anxiety relief. Furthermore, the natural environment did not seem to have a significant effect on stress/anxiety relief, instead the aquatic landscape had a more significant and positive effect and contributed to the direct reduction of stress/anxiety (Wang, et al., 2019).

## 5. Conclusions

Finally we underline the importance of the digital technologies in education domain for stress control and reduction, that is very productive and successful, facilitates and improves the assessment, the intervention and the educational procedures via Mobiles which brings educational activities everywhere [31-39], various ICTs applications which are the core supporters of education [40-73], AI, STEM & ROBOTICS which raise educational procedures into new levers of performance [74-85], and games which transforms the education in a very friendly, antistress and enjoyable interaction [86-93]. Additionally, the enhancement and combination of ICTs with theories and models of metacognition, mindfulness, meditation and emotional intelligence cultivation [94-153] as well as with environmental factors and nutrition [27-30], accelerates and improves more over the educational practices and results, in antistress fight for ASD students.

In order for the child's immersion in the virtual reality environment to be as successful as possible, it is important to isolate the child from the real world, overlaying real world stimuli with virtual ones created by the virtual reality system. Of the five senses, the most important in descending order are vision, hearing and touch. Thus of primary importance is the fact that the virtual reality system to be configured should provide a stereoscopic image, i.e. two images from different angles, one for each eye of the user, in order to create a sense of depth in space. At the same time, the presence of stereoscopic sound will help the child with ASD to understand what is happening around him in the virtual space that surrounds him in a very natural way, while at the same time it will exclude the child from the sounds of the real world, which could ruin his virtual experience. Finally, touch, can be used with appropriate devices either to allow the child to feel the world, e.g. touching an object and feeling resistance, or to guide the user by facilitating him/her to perform certain actions, e.g. modelling 3D objects. All of the above will be combined with the detection of the user's movements with appropriate tracking devices, so that the virtual environment will behave like the real one, and the whole experience of the child with ASD can be highly realistic. The VR tool will be image-based and will contain avatars so that the child can be embedded in the virtual environment in the form of real video as well as avatar, and can participate in the 3D distributed virtual environment either as a conventional avatar. Image-based virtual reality systems have gained popularity in

the computer graphics and computer vision communities. When creating realistic models, the acquired 3D data is accurately registered.

From the conclusions drawn from the above literature review, it is found that a person with ASD being in a virtual VR context that is appropriately designed to promote complete calmness can reduce stress levels. In this way, this tool will also provide an outlet for the child in cases of intense crisis and stress events. The virtual environment can be appropriately designed with visual stimuli to respond to the stimuli that a brain with ASD needs to interact with, targeting the production of anti-stress hormones and neurotransmitters in order to promote calmness and enable the child to experience total relaxation in depth.

Then, just as importantly, through the interaction with virtual reality, the child with ASD is able to acquire social and communication skills, which he or she will be able to adopt in everyday life, thus improving his or her cognitive level and quality of life. At the same time, it is sought to enable the child to be guided in the development of his/her emotional intelligence and the cultivation of awareness through communication with the avatar in order to produce and understand his/her emotions.

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