Safety and efficacy of virtual reality for teaching life skills to children with autism

Virtual reality (VR) is a promising technology for helping individuals with autism spectrum disorder, especially children, learn practical life skills. However, its immersive nature raises the two questions: can individuals with autism interact successfully with VR tools, and do they suffer any negative sensory or physiological effects? Since the 1990s, various studies have shown that VR, as well as non-immersive virtual environments (VE) are both safe and effective for individuals on the spectrum.

VR headsets

One of the first studies on the use of VR with individuals with autism was conducted by Strickland et. al. (1996), who examined whether children with autism could tolerate and respond to VR. Two children, aged 7 and 9, both with mild to moderate autism, used VR headsets that displayed a computer-generated simulation of crossing the street. They were able to wear the headset, which was much heavier and bulkier than modern technology, and track moving objects with eye and body movement. Both could verbally identify the objects and walk around the computer-generated world, and one was able to manipulate a movable object using the hand controls. However, it was not clear whether the children would translate their experience to a real street-crossing situation, or whether they would tolerate the headset for longer than the 5-minute limit that was used in the study.

More recently, Newbutt et. al. (2016) tested modern headset technology (the Oculus Rift) with 29 individuals with autism, aged 17-52. The study was conducted in two phases: the first included three virtual scenarios lasting 10 minutes total, and the second included two more complex scenarios lasting 25 minutes total. The scenarios were computer-generated, with high-quality graphics. Four participants were unable to complete the first phase because of dizziness and tiredness, but most experienced no negative physiological effects. Overall, the group reported a strong sense of presence and immersion.

It is also worth mentioning that a study of individuals with autism using augmented reality (AR) glasses (e.g. “Google Glass”) showed that nearly all participants tolerated the glasses for over an hour (Sahin, Keshav, Salisbury, & Vahabzadeh, 2017). The study included 21 children and adults, ages 4-21, and only two participants were unable tolerate the device. AR glasses are different from VR headsets in that they superimpose small images on the normal field of vision, rather than replacing the whole field of vision with an image. However, it is useful to note that this technology also produced few adverse effects.

Between 1997 and 2016, there were no published studies using VR headsets with individuals with autism, largely because the technology was costly, uncomfortable, and seemed to provide few advantages over similar programs displayed on desktop computers. The two studies described above show that VR technology is comfortable and safe for individuals with autism, but they do not demonstrate whether the skills learned in a virtual environment translate to the real world. For that, we must look to studies conducted using other technologies.

CAVE virtual environments

Some researchers have investigated the response of children with autism to a CAVE (cave automatic virtual environment), in which images are projected on all sides of a room to create an immersive experience. Wallace et. al. (2010) compared the responses of 10 adolescents with autism and 14 typically developing adolescents to computer animated scenes, such as a residential street and a school playground, which the participants viewed but could not interact with. Both groups experienced a similar sense of presence and engagement. Typically developing children were better able to judge the social desirability of the avatar's actions in the simulation, showing that the social difficulties of children with autism can be replicated in a virtual environment. Matsentidou and Poullis (2014) conducted a study in which twelve children, 9 to 10 years of age, participated in simulated scenarios, such as being alone and lost in an unfamiliar place. The participants had no problems using the immersive VR and did not show any discomfort.

Not only is the CAVE safe and useful for replicated real-world scenarios, but some researchers have demonstrated that children with autism make measurable learning gains with its immersive simulations. Ip et al. (2016) created a program to help children with autism make the transition from kindergarten to elementary school, which included various CAVE simulations of relevant social situations, like taking the school bus. Among the 100 participants, the results showed significant improvement in standard tests of social skills and anxiety. Tzanavari et al. (2015) used a CAVE simulation to teach street-crossing skills to six children with low-functioning autism, and four showed marked improvement in a real street-crossing situation. This is encouraging evidence that learning gained through simulation can be carried into the real world.

Desktop virtual environments

Although a simple desktop setup is less visually immersive than a headset or CAVE, it can be used for the same type of educational simulation. If children with autism can learn practical skills in such an environment, is it likely that these benefits translate to VR headsets.

An important study by Mineo, Ziegler, Gill, and Salkin (2009) established that children with autism engage more deeply with VR experiences than normal video, even when viewed on a desktop screen. Participants watched four scenarios: an animated video, a video of themselves, a video of a familiar person interacting with a VR simulation, and the VR simulation itself. Although the video of themselves won the longest gaze, both VR conditions prompted more vocalizations. This suggests that VR is a good medium for capturing the attention of children with autism for training and coaching purposes.

There is also evidence that individuals with autism can interact successfully with desktop simulations. Parsons, Mitchell, and Leonard (2004) examined the basic navigational skills of twelve adolescents with autism, compared to an IQ-paired group of typically developing teens, in an interactive desktop simulation of a café. Participants could move around and interact with other characters, for instance, by buying food with virtual money. Most participants with autism interacted with the virtual environment about as well as their control group pair, showing their understanding of its representational nature and ability interpret the beliefs of the characters. With training in how to use the technology, the participants with autism even out-performed an untrained control group of typically developing adolescents. However, a few participants tended to navigate inappropriately, bumping into or walking between characters in the scene. This could not be attributed to motor skill impairment and may indicate a poor understanding of personal space boundaries.

Further studies have measured gains in social skills after training with simulations. A follow-up study by Mitchell, Parson, and Leonard (2007) showed that using the interactive café simulation in conjunction with videos of a real café can significantly improve judgment and reasoning in social situations for participants with autism. A similar study by Kandalaft et al. (2013) tested a desktop simulation designed to improve the social function of young adults with autism, which included both casual and job-related social situations. Although conversation skills did not change, the training led to significant improvement in recognition of emotion and of other people's thoughts. In both these studies, however, it is not clear how long this learning persists or whether the study participants will apply it in real life.

There is some evidence that desktop-based VR training can improve real-life practical skills for individuals with autism. Josman, Ben-Chaim, Friedrich, and Weiss (2008) tested the efficacy of a desktop simulation for teaching children and adolescents with autism to cross the street, similar to the CAVE simulation used by Tzanavari (2015). All six participants improved their street-crossing skills within the simulation, although some required support to use the technology correctly and stay on-task. When tested in a protected real-life street crossing situation, half of the group showed significant improvement. Although the sample size of this study is small, the results show promise that at least some children with autism can benefit from such training.

Conclusion

Research has clearly shown that VR has great potential as a tool for teaching life skills to individuals with developmental disorders. Across technologies, study participants have demonstrated their ability to engage with simulations, with few negative emotional or physiological reactions. Beyond that, VR experiences have produced learning gains, measured not only by tests of social judgment, but also by assessments of activities performed in the real world.

However, the research remains sparse, with few participants in each study and a small number of studies overall, especially regarding the use of VR headsets. For a more robust understanding of VR as a learning tool for individuals with autism, the research community must focus on conducting larger studies with a wider variety of learning objectives and simulation designs. In particular, no study to date has investigated the use of 360-degree video, as opposed to computer-generated graphics, for immersive VR. As VR becomes more accessible, a broader and deeper academic literature would support its use as an educational tool for individuals with autism and help them achieve greater independence and quality of life.

References

Ip, H., Wong, S., Chan, D., Byrne, J., Li, C., Yuan, V., . . . Wong, J. (2016). Virtual Reality Enabled Training for Social Adaptation in Inclusive Education Settings for School-Aged Children with Autism Spectrum Disorder (ASD). *Blended Learning: Aligning Theory with Practices.* Beijing: International Conference on Blended Learning.

Josman, N., Ben-Chaim, H. M., Friedrich, S., & Wiess, P. L. (2008). Effectiveness of virtual reality for teaching street-crossing skills to children and adolescents with autism. *International Jounal on Disability and Human Development, 7*(1).

Kandalaft, M., Didehbani, N., Krawczyk, D. C., Allen, T. T., & Chapman, S. B. (2013). Virtual Reality Social Cognition Training for Young Adults. *Journal of Autism and Developmental Disorders, 43*(34).

Matsentidou, S., & Poullis, C. (2014). Immersive visualizations in a VR Cave environment for the training and enhancement of social skills for children with autism. *International Conference on Computer Vision Theory and Applications.* Lisbon: IEEE.

Mineo, B. A., Ziegler, W., Gill, S., & Salkin, D. (2009). Engagement with Electronic Screen Media Among Students. *Journal of Autism and Developmental Disorders, 39*.

Mitchell, P., Parson, S., & Leonard, A. (2007). Using Virtual Environments for Teaching Social Understanding to 6 Adolescents with Autistic Spectrum Disorders. *Journal of Autism and Developmental Disorders, 37*.

Newbutt, N., Sung, C., Kuo, H.-J., Leahy, M. J., Lin, C.-C., & Tong, B. (2016). Brief Report: A Pilot Study of the Use of a Virtual Reality Headset. *Journal of Autism and Developmental Disorders, 46*(3).

Parsons, S., Mitchell, P., & Leonard, A. (2004). The Use and Understanding of Virtual Environments by Adolescents with Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders, 34*(4).

Sahin, N. T., Keshav, N. U., Salisbury, J. P., & Vahabzadeh, A. (2017). Cool Enough for School: Second Version of Google Glass Rated by Children Facing Challenges to Social Integration as Desirable to Wear at School. *bioRxiv (preprint)*.

Strickland, D., Marcus, L. M., Mesibov, G. B., & Hogan, K. (1996). Brief report: Two case studies using virtual reality as a learning tool for autistic children. *Journal of Autism and Developmental Disorders, 26*(6).

Wallace, S., Parsons, S., Westbury, A., White, K., White, K., & Bailey, A. (2010). Sense of presence and atypical social judgments in immersive virtual environments: Responses of adolescents with Autism Spectrum Disorder. *Autism*.