Benefits of Technology Executive Summary

Autism spectrum disorder (ASD) is a developmental disability affecting about 1 out of 59 children (Baio 2018), and is commonly characterized by difficulties with communication, social interaction, perspective taking, and emotional regulation (Baio, 2014; Centers for Disease Control and Prevention, 2016). Children with ASD usually have difficulty understanding other people's emotions or understanding perspective of others (perspective taking) (Sticher, Laffey, Galyen, & Herzog, 2014).

It has been reported that many people with ASD have an affinity for computers and video games, which could increase their motivation for engaging in these programs (Ferguson, Gillis, & Sevlever, 2013). The following paper is a brief summary of a literature review focusing on the use of virtual-reality (VR) in clinical and educational settings with children and youth with ASD. This literature review turned up 182 studies. Of these, 21 fit our criteria. We have organized those 21 studies into three sections: social participation, learning, and daily skills.

Social participation: It has been shown that the use of virtual learning environments have potential to improve **social functioning** among individuals with ASD. Many studies have found that children with ASD are able to improve their social skills, understanding of empathy, and decision-making when using an educational program through virtual environment such as a 3D computer game (Rice et al., 2015; Cheng et al., 2010; Cheng, Chian, Ye & Cheng, 2010; Cheng, Huang, & Yang, 2015; Didehbani et al., 2016; Chung, Han, Shin, & Renshaw, 2016). More specifically, VR-based programs have been found to increase *communication skills* such as, initiation, greeting, and conversation-ending in children with ASD (Ke & Im, 2013). Previous studies have also shown that using VR systems for improving *play skills* results in a significant advancement in play abilities, an improvement in collaborative play, and increased frequency and duration of effective social interactions in children with ASD (Herrera et al., 2008; Gal et al., 2016; Ozen, 2015; Bai, Blackwell, & Coulouris, 2015).

Using a virtual environment can also improve **emotion recognition** and enhance empathy with others in individuals with ASD. Previous studies have illustrated that the use of a human-like avatar (i.e., characters on the screen) in a virtual-learning-environment can help individuals with ASD to better recognize emotions and respond to them appropriately (Moore et al., 2005; Chen, Lee, & Lin 2015; Kim et al., 2015). Researchers have also observed that using video modelling in a VR environment can help children with ASD to maintain their attention while simultaneously helping them to understand facial expressions and emotions (Chen, Lee, & Lin, 2016).

Learning: The use of a virtual-learning environment to improve **cognitive skills** in individuals with ASD is another area of investigation. Researchers have found using VR results in an increase in memory performance for children with ASD (Hsu & Teoh, 2017). These authors analyzed the use of a novel avatar interviewing aid during memory interviews, scavenger hunts, and intelligence assessments, and found that using an avatar was a more "ASD friendly" method of improving recall memory in young children with ASD when compared to using a human interviewer. Using a virtual-learning environment has also been found to be effective for teaching school curriculum to adolescents with ASD. One study found that using 3D virtual learning as a means of distance education increases social competence through knowledge and social practice for youth with ASD (Stichter et al., 2014). Likewise, another study found that use of distance teaching program increases embodied presence and copresence (the sense of one's own avatar, the sense of proximity of other user's avatar, and the sense of the social actor "behind" the other avatar) in almost all of the online activities (Wang et al., 2016).

Daily Skills: A few studies have found benefits in the use of a virtual reality systems to improve specific daily skills. For example, using a VR café system was beneficial in teaching teenagers with ASD how to sit or how to maneuver through tables and chairs while in a restaurant (Parsons et al., 2004; Mitchell et al., 2007). Alternatively, it has also been found that VR can be used to teach safety skills such as street-crossing, fire safety, and tornado safety (Self, Scudder, Weheba, & Crumrine, 2007; Goldsmith, 2009). One study found that using a fully-immersive virtual room is an effective treatment for addressing some phobias or fears in individuals with ASD (Maskey et al., 2014).

Overall, these studies suggest that using a virtual-learning environment for children and youth with ASD can be a beneficial way to improve social skills and emotion recognition, as well as teaching specific daily skills and learning skills. The existing research supports the use of VR for learning and/or therapy for children and youth with ASD. However, none of the studies we reviewed received a strong score on the Quality Assessment Tool from the Effective Public Health Practice Project. 14 of the studies reviewed received a weak score, and 7 studies received a moderate score. This suggests that future research should focus on a more rigorous study design to strengthen the evidence-base. As well, the utilization rate of current technologies in rehabilitation and/or learning environments is low, potentially due to ambiguities regarding the cost-effective analysis and clinical decision making of using VR for the wide heterogeneous group of individuals with ASD. Future research should analyze this further and propose a framework on what are the effective ways to use individualized VR platforms to help with learning and/or therapy related to social participation for children with autism in clinics, schools, community centres, and homes.

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