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COMMENTARY

Considering virtual reality in children's lives

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KEYWORDS Virtual reality; children; head-mounted display; virtual environment; immersive technology; virtual embodiment; virtual doppleganger; immersive VR; avatars

Companies are investing billions of dollars into creating virtual reality (VR) hardware and content, and millions of people have already gained access to VR technology (Solomon, 2014; Somaiya, 2015; Wohlsen, 2015). For instance, on 8 November 2015, the New York Times sent a basic and inexpensive VR headset to millions of its Sunday newspaper subscribers. In Sweden, McDonald's restaurants have sold kids' meals in boxes that can be transformed into VR "Happy Goggles" featuring McDonald's-branded games (Harwell, 2016). Market research firms expect 14 million VR devices to be sold worldwide this year (Harwell, 2016). With the public gaining access to VR at faster rates than ever before, children are increasingly likely to use this technology in their daily lives.

Immersive VR experiences have been shown to powerfully affect adults' thoughts, behaviors, and attitudes, but little is known about VR's effects among children. The research that exists on VR and children has been related to its use in clinical or medical settings for pain distraction (Shahrbanian et al., 2012), for assessing ADHD and Autism Spectrum Disorder (Bellani, Fornasari, Chittaro, & Brambilla, 2011; Pollak et al., 2009), and for education such as teaching life skills for hearing-impaired or deaf children (Vogel, Bowers, Meehan, Hoeft, & Bradley, 2004). In non-medical settings, VR has been used for a variety of purposes such as implementing an anti-smoking intervention for teens (Nemire, Beil, & Swan, 1999), and measuring children's crosswalk behaviors (Simpson, Johnston, & Richardson, 2003). Among VR studies that include any child under the age of 18, little research has examined the psychological influence of VR on human development. Segovia and Bailenson (2009) conducted one of the few studies testing the psychological effects of immersive VR by examining the technology's influence on children's memories.

In this article, we define immersive VR and discuss how some of its unique affordances relate to child development. We discuss how virtual embodiment (i.e., children's avatars), interactions with socially responsive virtual characters, and the setting of the virtual scenarios could influence children and youth's lives. In addition, we present potential areas for future research.

Immersive VR technology blocks out the physical world and provides rich sensory feedback that utilizes sight, sound, touch, and smell (with sight and sound most commonly used).

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From a psychological standpoint, VR is the feeling of non-mediation; the sensation that there is no technology between the user and his or her sensory experience (Blascovich & Bailenson, 2011; Lombard & Ditton, 1997; Steuer, 1992). VR tracks users' movements and the virtual environment changes according to those movements. A virtual reality headset, called a head-mounted display (HMD), is one type of hardware that can create immersive virtual environments that feel extremely real (i.e., having a wide field of view; Cummings & Bailenson, 2016). Through an HMD, users experience three-dimensional views of a virtual environment, and feel as if they are embedded in the media content.

Users are represented in VR through their avatars, digital representations that they control in real time. Using an HMD, children can look down from a first-person point of view to see their bodies as any race, gender, age, or even organism. VR users treat their avatars as if they were their real bodies (Maister, Slater, Sanchez-Vives, & Tsakiris, 2015), which then influences their psychology, physiology, and perceptions (Banakou, Groten, & Slater, 2013; Moseley et al., 2008; Peck, Seinfeld, Aglioti, & Slater, 2013; Salomon, Lim, Pfeiffer, Gassert, & Blanke, 2013). Embodiment in VR may be particularly compelling compared to less immersive mediums, because children can control their avatar with their body movements, and the view of their physical body is replaced with their virtual body. This has implications for the way that children and youth experience health and social interventions.

From a health perspective, virtual embodiment can help facilitate children's physical rehabilitation. VR could increase children's self-efficacy and adherence to their exercises by having their virtual bodies appear to move more fluidly than their physical bodies. Won et al. (2015) tested this idea using VR to treat complex regional pain syndrome among pediatric patients. Children completed a target-hitting task in VR using three types of virtual embodiment: (1) their avatar's body movements were similar to their own, (2) their avatar's limbs had increased flexibility, and (3) the control of their avatar's limbs was switched (i.e., using arm movements in the physical world to control their avatar's legs). The results of this case study showed the potential for VR as an engaging rehabilitation tool. Future research could examine the effects that novel embodiment has on improving children's long-term health and care.

Children and youth can take on different roles in VR as a form of social intervention. VR could be used to help with social skills training with children with Autism Spectrum Disorder by allowing them to practice verbal and non-verbal behaviors (Bellani et al., 2011). Virtual embodiment could be used for empathy training by allowing youth and children to take on the role of a different race, gender, nationality, or social class, and to live a day in the life of that person. Research with adults has shown that VR can reduce implicit race bias when users embody an avatar of a different race (Peck et al., 2013). In addition, VR can also act as a safe environment for individuals to practice their social cognition skills without major social repercussions. For instance, adolescents and teens could practice how to effectively intervene when another child is being bullied without having to worry about being a victim of physical or verbal abuse if they choose an action that escalates the situation.

Virtual embodiment can also occur through a third-person perspective. Children can see a photorealistic version of themselves be controlled by a computer algorithm. They can see themselves perform actions that they've never engaged in. These types of representations are known as virtual doppelgangers (Blascovich & Bailenson, 2011). A virtual doppelganger is different than an avatar because a computer controls the digital representation in real-time as opposed the child's actions. Seeing the actions of a virtual doppelganger can have powerful effects on real world behaviors. Among young adults, virtual doppelgangers have been shown to influence their exercise and eating habits (Fox & Bailenson, 2009; Fox, Bailenson, & Binney, 2009), increase their likelihood to financially invest in their future (Hershfield et al., 2011), and affect the type of products that they prefer (Ahn & Bailenson, 2011).

Currently, only one study has examined the effect of virtual doppelgangers with children in immersive VR. The results of a study by Segovia and Bailenson (2009) showed that when young elementary school children saw their virtual doppelganger swimming with orca whales they confused it as happening in real life. Although past research with television has shown that by the age of five, children tend to distinguish fantasy from reality (Flavell, Flavell, Green, & Korfmacher, 1990; Richert, Robb, & Smith, 2011), immersive VR may make it more challenging for children to distinguish fiction from reality. VR creates the illusion of being surrounded by the content, which can blur the lines between real life and the virtual world. Future research will need to investigate why and how this type of virtual embodiment affects children and what ages are particularly susceptible to this type of experience.

Children will likely use their avatars to interact with other virtual or media characters. Media characters that are embodied and socially response have been shown to increase children's trust and facilitate learning (Anderson et al., 2000; Brunick, Putnam, McGarry, Richards, & Calvert, 2016; Calvert & Richards, 2014). VR could enhance learning, by incorporating virtual teachers that change dynamically to the needs of the student (e.g., Bailenson et al., 2008). For instance, a virtual teacher could pause a class lesson for a child that needs additional help, but through the viewpoint of the rest of class, continue on with the lesson.

In immersive VR, users feel as if they are sharing the same physical space with virtual characters, making the characters' non-verbal cues very salient. These non-verbal cues (e.g., eye contact) could unconsciously influence children's attitudes and behaviors. In addition, computer algorithms in VR could easily track children's movements and have virtual characters use that information in their actions. For example, virtual characters in VR are seen as more persuasive when they subtly mimic the head movements of an adult (Bailenson, Beall, Loomis, Blascovich, & Turk, 2004).

In addition to children's avatars and other virtual characters, children can experience a multitude of environments through VR. By altering the social context, immersive VR provides great opportunities for creating engaging learning environments and assessing children's behaviors. A virtual classroom can be more than chairs, desks, and a teacher. For instance, middle school students have used VR to learn about the social behaviors of gorillas by visiting a virtual zoo, and embodying a young gorilla (Allison & Hodges, 2000). Children can learn by interacting with their content through virtual field trips. Immersive VR can place children in a different country or historical period and allow them to experience the sights and sounds of that community. Virtual field trips would provide students with a more affordable way to learn about the world.

VR can also collect thousands of data points about children's behaviors while they use the technology. The tracking technology of VR measures users' body movements, and this data can be used to provide insight on children's psychology. For example, VR has been used in several studies to diagnosis children with ADHD by measuring their attentional focus (e.g., Bioulac et al., 2012). In Bioulac et al. (2012), children were placed in a virtual classroom with distractions, while the HMD they wore tracked where they looked at any given moment; researchers shared the viewpoint of each child. By altering the social context, researchers gained a better understanding of how children with ADHD experience classrooms.

When users enter immersive virtual environments, they are often psychologically transported to that location. The research with VR as a pain distraction tool provides evidence that VR has unique abilities that make virtual content seem real to children. Immersive VR has been shown to reduce children's physical and emotional pain during cancer treatments (e.g., Gershon, Zimand, Pickering, Rothbaum, & Hodges, 2004), wound care (e.g., Hoffman et al., 2008; van Twillert, Bremer, & Faber, 2007), and dental procedures (Aminabadi, Erfanparast, Sohrabi, Oskouei, & Naghili, 2012). In these specific virtual environments, typically children do not see a virtual body, putting less emphasis on the body and possible pain it could feel. VR pulls children's minds away from the physical world to focus on the virtual environment itself. By being psychologically transported to an immersive VR environment, children can escape the pain that they would usually experience. Even with little to no interactivity, immersive VR has been effective in reducing children's and youth's reported levels of pain (e.g., Dahlquist et al., 2007; Law et al., 2011) suggesting that technological immersion has special attributes.

Currently, no research has examined how distraction in immersive VR influences children in non-medical settings. It is unclear what benefits or risks are related to children being mentally pulled into an immersive virtual environment in their daily lives. It could be that it is particularly challenging for children to stop using immersive virtual environments or for them to remember where they are located in the physical world because the VR content is highly engaging.

The ability of VR to psychologically transport children could vary based on the child's age. The more salient a symbol or digital representation, the harder it is for young children to understand that it stands for something else (DeLoache, 2000, 2004; Troseth & DeLoache, 1998). VR may provide a sensory-rich experience that could be particularly challenging for some children to ignore. Future research will need to examine how the saliency of immersive virtual environments relates to when certain cognitive abilities develop.

Using virtual embodiment, socially responsive virtual characters, and engaging virtual environments, immersive VR has the potential to transform children's health, educational, and entertainment interactions. Research with adults has shown that people respond to immersive VR content as if it were real, and that VR influences how they think and behave. While there are some research studies that examine VR among child populations – primarily from a medical perspective – there are still many unanswered questions about immersive VR's influence on children's development. VR can act as a powerful tool that creates compelling experiences. How we choose to use this tool can determine how effective VR could be at enhancing children's lives.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Jeremy N. Bailenson, Thomas More Storke Professor in the Department of Communication, is the founding director of Stanford University's Virtual Human Interaction Lab. His research studies the psychology of Virtual Reality (VR), in particular, how virtual experiences lead to changes in perceptions of self and others. His lab builds and studies systems that allow people to meet in virtual space, and explores the changes in the nature of social interaction. His most recent research focuses on how VR can transform education, environmental conservation, empathy, and health.

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