Virtual Reality in Pediatric Psychology

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abstract

Virtual reality (VR) technologies allow for controlled simulations of affectively engaging background narratives. These virtual environments offer promise for enhancing emotionally relevant experiences and social interactions. Within this context, VR can allow instructors, therapists, neuropsychologists, and service providers to offer safe, repeatable, and diversifiable interventions that can benefit assessments and learning in both typically developing children and children with disabilities. Research has also pointed to VR's capacity to reduce children's experience of aversive stimuli and reduce anxiety levels. Although there are a number of purported advantages of VR technologies, challenges have emerged. One challenge for this field of study is the lack of consensus on how to do trials. A related issue is the need for establishing the psychometric properties of VR assessments and interventions. This review investigates the advantages and challenges inherent in the application of VR technologies to pediatric assessments and interventions.

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TABLE 1 Comparison of VR Systems

	PC-Based VR		Mobile-Based VR			Console-Based VR	Stand-alone	
System	Oculus Rift	HTC VIVE	Samsung Gear VR	Google Cardboard	Google Daydream	PlayStation VR	Allwinner VR	Snapdragon 820 VR
Cost, US$	599	799	99	10–50	69–149	399	99–249	399–450
Hardware requirements (US$)	High-end PC (>1000)	High-end PC (>1000)	High-end Samsung phone (>600)	Middle or high-end Android phone or iPhone (>299)	High-end Android phone (>499)	PS4 (299) or PS4 Pro (399)	None	None
Resolution	2160 × 1200	2160 × 1200	2560 × 1440	Depends on the phone (minimum 1024 × 768)	Depends on the phone (minimum 1920 × 1080)	1920 × 1080	1920 × 1080	2560 × 1440
Refresh rate	90 Hz	90 Hz	60 Hz	60 Hz	90 Hz minimum	120 Hz	60 Hz	70 Hz
Field of view	110°	110°	101°	from 70°	96°	100°	90°	92°
Body tracking	Medium or high: head tracking (rotation) and positional tracking (forward and backward)	High: head tracking (rotation) and volumetric tracking (full room size is 15 × 15 ft for movement)	Medium: head tracking (rotation)	Medium: head tracking (rotation)	Medium: head tracking (rotation)	Medium or high: head tracking (rotation) and positional tracking (forward and backward)	Medium: head tracking (rotation)	Medium or high: head tracking (rotation) and positional tracking (forward and backward)
User interaction with VR	High (by using a joystick or controllers)	High (by using controllers)	Medium (by using gaze, a built-in pad, or a joystick)	Low (by using gaze or a button)	Medium (by using gaze or a joystick)	High (by using a joystick or controllers)	Medium (by using gaze, a built-in pad, or a joystick)	Medium (by using gaze, a built-in pad, or a joystick)
Software availability	Oculus store	Steam store	Oculus store	Google Play or iOS store	Google Play	PlayStation store	Google Play	Google Play

PC, personal computer.

BACKGROUND

Virtual Reality for Assessment and Training

Virtual reality (VR) is an emerging technology that can be considered the result of the evolution of existing communication interfaces toward various levels of immersion.[1] An important difference between VR and other media or communication systems is the sense of presence, the "feeling of being there."[2] Through merging of educational and entertainment environments (eg, gamification, VR, and edutainment), coupling of immersive technologies (eg, head-mounted displays [HMDs]) with advanced input devices (eg, gloves, trackers, and brain-computer interfaces), and computer graphics, VR is able to immerse users in computer-generated environments that reflect real-world activities.[3–5] Within this context, and within the field of VR more widely, there are many technologies that have been developed and used in educational and clinical settings. As such, there is a wide range of hardware available to researchers and practitioners. Table 1 provides a synthesis of currently available technology and highlights the various specifications, costs, and user interactions across a spectrum of devices. Although these VR technologies differ in their specification, size, and portability, the key affordances of VR (ie, immersion, presence, and ecological validity) remain. Therefore, it is likely some key findings (eg, acceptance, presence, immersion, limited negative effects) from previous work could be applicable across many current technologies.[6] Although the quality, graphic fidelity, and refresh rates might vary across platforms (as highlighted in Table 1), the nature of the VR immersive environments and presentation of visual (and audio) stimuli help to ensure similar user experiences across all platforms.

The availability of much more affordable devices (as shown in Table 1) illustrates that VR hardware has the potential to become more accessible to a much wider demographic than before. Therefore, the extent to which the key affordance of presence is supported by the different VR technologies is a central research question for the field if we are to really understand what features supported by the different hardware are necessary and sufficient for supporting effective and authentic assessment and learning with VR for a much wider group of children. In other words, VR offers an important pathway for narrowing the digital gap nationally and internationally if we can establish how a sense of presence can be achieved in the most accessible and available technologies.

Current State of the Science

Recent advances in VR technology allow for improved efficiency in administration, presentation of stimuli, logging of responses, and data analyses.[7] These features have allowed VR platforms to emerge as promising tools for pediatric cohorts in a number of domains. Examples from recent research and reviews (within the past 10 years) include the following:

- Neurocognitive assessment[8]
- Psychotherapy[9]
- Rehabilitation[10]
- Pain management[11]
- Prevention and treatment of eating disorders[12]
- Communication training[13]
- Vocational readiness training[14]
- Social skills training[15]

Within this context, VR technology can allow instructors, therapists, neuropsychologists, and service providers to offer safe, repeatable, and diversifiable interventions that can benefit assessments and learning in both typically developing children and children with disabilities.[16]

Entertainment and Educational Environments

VR and augmented reality platforms are rooted in gaming, simulation, and entertainment experiences. Augmented reality overlays virtual objects over a real environment, resulting in a mixed reality that can be used for student-centered learning scenarios. Given the merging of educational and entertainment environments, virtual environments (VEs) and augmented environments have the potential to be a "positive technology" that can improve the quality of children's experiences.[17,18] For example, Active Worlds, Second Life, and ecoMobile are platforms that have been advocated as promoting more active exploration, engagement, student-centered, hands-on learning; better understanding of complex subjects; and more authentic, collaborative, and experiential opportunities for solving real-life problems.[19]

The Google Expeditions Pioneer Program[20] is a good example of this emerging trend, which allows teachers to take their students on virtual journeys using an application installed on the students' smartphones. In addition to being teaching and learning tools, VR allows for data capturing of learners' attitudes, behavior changes, and "aha" moments. Such a portfolio of assessments helps serve as a foundation for educators to develop formative assessment loops, address individual needs, and design better learning opportunities.[21] In higher education, VR technologies may help prepare students for future work places in science, technology, engineering, mathematics, business, and medicine. This is especially the case in training skills and performance that carry high risks (eg, driving, flying, conducting a surgery, managing investments).

Augmented reality, too, is an effective experiential learning tool.[22] On 1 side, it uses virtual objects to provide nondirective but targeted suggestions that help learners to develop knowledge and skills effectively. On the other side, it allows real-time interactivity in an ecological setting. In particular, as demonstrated recently by the worldwide success of Pokémon Go, it also has the potential of improving public health by promoting physical activity.[23]

A focus on positive technology also provides new ways of thinking about the locus and, therefore, solutions of the different challenges or problems faced by children with neurocognitive difficulties.[24] For example, rather than developing VR to fix the impairments of the child, VR could be developed to provide better insights and awareness into the difficulties experienced by individuals so as to promote better understanding from the wider public. The "Too Much Information" project of the National Autistic Society in the United Kingdom is a good example of this kind of approach (http://www.autism.org.uk/VR).

FUTURE RESEARCH

One area of future research that will be of interest to clinical scientists is the performance of large-scale randomized controlled trial (RCTs). Although quantitative reviews of VR interventions have revealed statistically large effects on a number of affective domains,[25] future studies can increase the confidence in these findings through the inclusion of control groups and performing RCTs. Furthermore, there is need for future studies aimed specifically at establishing the ecological validity and other psychometric properties of VR assessments and interventions for clinical, social, and affective neuroscience research.[26]

After the establishment of psychometric properties of VR protocols, future work will be assisted by adopting procedures for standardized reporting of RCT outcomes. This is especially important in the context of new designs and relatively untested features of technology. A potential aid for future research can be found in the Consolidated Standards of

Reporting Trials guideline that ensures readers have the basic information necessary to evaluate the quality of a clinical trial.[27]

RECOMMENDATIONS

Clinicians and Providers

Although VR-based neuropsychological assessments are often referenced for their promise of enhanced ecological validity,[3,26] there are potential practical limitations that should be considered. Some VR-based assessments offer automated presentations that do not allow flexibility for clinical examiners to interrupt or test the limits during assessment. Future development of VEs should allow for flexible presentations, wherein clinicians may adjust graphics, stimuli, and task parameters via an interactive user interface. Moreover, the dearth of established guidelines for the development, administration, and interpretation of these assessments could lead to important psychometric pitfalls. Although these limitations are important to consider, advances in VR technology will allow for continued enhancements in approximations of real-world cognitive and affective processes.

There is also the potential for unintended negative effects of exposure to VEs; stimulus intensity, if taken too far, may exacerbate rather than ameliorate a deficit. Although this is an important concern, studies using VR with students diagnosed with neurodevelopmental disorders have been performed with no reported negative effects.[5,8,28,29] As we adopt newer and more immersive technologies it is important that researchers continue to consider the potential negative effects (eg, dizziness, sickness, displacement) to ensure that wearable technologies (eg, HMDs) can provide an acceptable space for children to use them, especially children with disabilities. With this said, there is some evidence that suggests children do not experience HMDs any more negatively than screen-based media.[5,8,28,29] Taken as a whole, the need to validate and confirm the acceptance of evolving and new technologies is evident, and there is need for more research in this domain.

With this in mind, there is a need, before we enter into VR RCTs, design, and intervention programs, to fully validate and understand users' perspectives and ensure that ethical guidelines are established. This could be done in either laboratory-based or in situ settings; however, careful attention will need to be placed on developing protocols to ensure the voices of participants are always heard in any research endeavor involving VR technologies.

The introduction of affordable HMDs (eg, Oculus Rift, Samsung Gear VR, Google Cardboard) makes VR an increasingly popular entertainment and learning venue. However, the unmonitored use of VR for entertainment has raised concerns over the years. For example, Segovia and Bailenson[30] conducted a study examining the use of VR in children. They found that children exposed to VEs do not always differentiate between VR-based memories and memories formed in the real world. Although these findings need to be replicated in additional studies, the implications demonstrate that unmonitored and entertainment-based VR platforms may not be appropriate for all children. Moreover, the merging of VR with gaming technologies will open VR to concerns that have been raised for gaming and entertainment technologies: sedentary lifestyle, cyber addiction, violence, social isolation, desensitization, and safety. Additional research is needed in these areas.

Policy Makers

An important challenge in the design and development of VR technologies is the difficulty involved in putting together interdisciplinary research teams for developing appropriate interventions. Furthermore, there is increasing recognition that representatives of intended user groups should also be included to achieve a better fit between identified needs and proposed solutions. Although not without difficulties, such approaches also align with increasing awareness of the need to involve, for example, members from the clinical and educational communities in these research agendas more widely. Our main recommendation here is that policy makers, including funders, need to support and encourage more user-centered design approaches to VR development and evaluation to ensure that end users' needs and priorities are more effectively met in research programs and projects.

Educators

As mentioned earlier, VR offers great potentials for teaching, learning, assessment, and interventions. Although VR can provide a safe environment for students to gain skills, it usually requires actual experiences to fully master a skill. Poorly designed VR environments may lead to misunderstanding or faulty training results. In addition, VR can provide authentic assessments and interventions in schools, where children and adolescents spend most of their time. The potential for VR technologies to be deployed in schools and used for distance learning is encouraging even if it is challenging. Its potential will be deepened by the diffusion of VR on smartphones.

It is the working group's consensus that investigations into these future research endeavors have the potential to inform policy, theory, and praxes. Specifically, the addition of VR platforms to pediatric assessments and interventions offers an opportunity for advancing our understanding of the cognitive, affective, psychosocial, and neural aspects of children as they take part in real-world activities.

ABBREVIATIONS

HMD: head-mounted display
RCT: randomized controlled trial
VE: virtual environment
VR: virtual reality

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