Children in virtual reality deserves more attention

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ABSTRACT

Cybersickness, a type of motion sickness induced by virtual reality (VR) experiences, has become an increasingly important concern as more children engage with immersive VR technologies. In this paper, we have summarized our findings from recent VR studies that used children as participants. Along with other factors, our focus was on the well-being of children, especially in terms of cybersickness. We have found that cybersickness measurement is severely underrepresented in these studies. With this article, we hope to bring awareness to the protection of children in VR studies. Further investigation on the effects of cybersickness in children, along with the root causes of this phenomenon, is warranted as a result of evolving VR technology.

CCS CONCEPTS

• **Human-centered computing** → **Virtual reality**; *Accessibility theory, concepts and paradigms*; *Accessibility technologies*; User centered design.

KEYWORDS

Children, Cybersickness, Accessibility, Virtual reality

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1 INTRODUCTION

Virtual reality (VR) is a rapidly evolving technology that has revolutionized the way we interact with digital media and entertainment. It provides users with an immersive and interactive experience, allowing them to explore digital environments and interact with virtual objects in a way that was previously impossible. While VR has many potential benefits, such as enhancing education and entertainment, it also comes with some risks. One of the major concerns associated with VR is cybersickness, a form of motion sickness that can occur when the visual and vestibular systems in the body are mismatched [15]. It can result in a range of symptoms, including nausea, dizziness, and headaches.

Virtual reality is becoming increasingly popular among children, especially gamers. Researchers are also using virtual reality in children in reducing pain [2], rehabilitation [23], education [19], improving attention [10], etc. Many of these studies are also done on children with special needs [8, 11, 20]. In this paper, we have investigated the current state of VR research that uses children as participants. We have discussed our findings in six categories: focus of the study, participant special group, number of participants, age range of participants, VR device used, and cybersickness measure. We found that very few research measured cybersickness, which is surprising since many research with adult participants use some form of cybersickness measurement (e.g., simulator sickness questionnaire (SSQ) [14]). Measuring cybersickness is equally if not more important for children since children are more prone to motion sickness [22]. Therefore, we have discussed more about the studies that reported cybersickness in table 1.

2 METHODS

To perform this literature review, a couple of steps were taken to ensure that the literature we reviewed was both the most relevant and modern in the industry. The first step taken was finding the most relevant articles for our literature review. This was done by web scraping the most relevant articles when searching for the keywords 'children' and 'virtual reality' on Google Scholar. One of the other criteria is that the article was published between 2022 and 2010. This search was done in July 2022, so all articles published after July 2022 were not included in this literature review. The links to each article were saved in an excel file with a total of 860 articles. To then get the most modern articles, the excel file was then sorted by year, putting the newest articles at the top. Now the articles are sorted by both date and relevance. For this literature review, all of 2022 and 2021 were chosen, which was 191 articles. The next step taken was to perform the literature review, summarize the articles, and describe five main details about each article. These six details were: the focus of the study, the participant special group, the number of participants, the age range of participants, the VR device used, and the cybersickness measure in the study. The results were then analyzed and synthesized into a table that included all the articles that contained a cybersickness measure.

3 RESULTS

During our literature review, we read 191 articles published between January 2021 and July 2022. After reading all the articles, we aggregated the data to give a summary of what was common in the articles. The categories are discussed below:

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3.1 Focus of the study

The first category we looked at was the focus of the study. There were six main categories that these studies focused on. These were: pain reduction (n = 36), rehab (n = 35), education (n = 33), summary (n = 8), attention (n = 4), and other (n = 39). The rest of the articles did not have a specific focus.

3.2 Participant special group

The next category we looked at was the special group involved in this study. In studies, there were five major categories for special groups. These were: neurotypical children (n = 60), autism spectrum disorder (n = 26), cerebral palsy (n = 22), other disabilities (n = 20), adolescents (n = 13), attention deficit hyperactivity (n = 11), and other (n = 40). The rest of the studies did not specify a special group.

3.3 Number of participants

The next category we looked at was participant size, which is the number of people who participated in each study. We categorized them into three different sizes. Small participation is when n < 20, medium participation is when n >= 20 and n <= 50, and high participation is when n > 50. We had a total of 43 small studies, 39 medium studies, and 44 large studies.

3.4 Age range of participants

The next category we looked at was the age distribution of the studies. Figure 1 shows how many studies each age group had participated in. The x-axis is the age, and the y-axis is the frequency of that age in a study.

3.5 VR device used

The next category we looked at was the VR device used in the study. There were five main categories of devices used. These were: unspecified head-mounted displays (n = 38), phone VR devices (n = 15), Oculus VR devices (n = 13), Wii Fit/Microsoft Kinect (n = 12), HTC VR devices (n = 7), and other devices (n = 25). Other studies did not mention any specific device.

3.6 Cybersickness measure

The last category we looked at was the cybersickness measure. Out of 191 articles, only 11 articles measured cybersickness, 8 articles excluded participants based on prior history of cybersickness, 11 articles acknowledged cybersickness, but did not measure or exclude participants based on cybersickness, and rest of the article did not mention cybersickness. Table 1 shows a summary of all studies that used a cybersickness questionnaire.

4 DISCUSSION

Our literature review revealed how studies use a cybersickness measure when children are the participants of a study. Out of the 191 articles examined, only 11 studies used a proper questionnaire. To make matters even worse, 161 studies did not make any effort to acknowledge the cybersickness or adverse symptoms participants may experience when using virtual reality devices. This evidence from our literature review helps prove the point that cybersickness measures should need more attention when children are involved

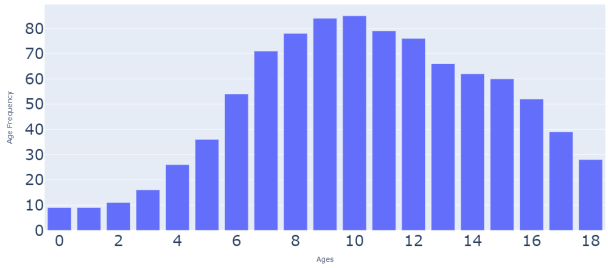

Figure 1: Age Frequency

in studies. Finally, the results of this review were restricted in some ways. One of the biggest limitations was the lack of a longitudinal study of how the number of studies with cybersickness questionnaires changed over the years. This was impossible for us to do due to time constraints. It would be interesting to review this topic more in the future.

5 CONCLUSION

This review summarizes the use of cybersickness questionnaires in VR studies that involve children. This literature review found that only a small number of studies measure cybersickness or even mention that it could have affected their study in some way. Not only can cybersickness negatively impact the study, but it can also negatively impact the participants in the study. It is a researcher's job to ensure the well-being of the participants in their study. This is even more important for children, especially those who are in a special group. Children with special needs, such as cerebral palsy or autism, may have difficulty expressing their true feelings or opinions during the study. From these findings, we can conclude that cybersickness measurement is not used enough in studies that put children in virtual reality.

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Table 1: Overview of studies measuring cybersickness in children

Author (Year): Title[Reference Number]	Participants	Task	Outcome Measures and Instruments	Cybersickness Measure	VR Description
Hundert et al. (2022) A Pilot Randomized Controlled Trial of Virtual Reality Distraction to Reduce Procedural Pain During Subcutaneous Port Access in Children and Adolescents With Cancer [13]	40	VR Games	Self reporting questionnaire on pain, distress, and immersiveness	Self reporting questionnaire on immersiveness and adverse side effects (dizziness and motion sickness)	Head Mounted Display with bluetooth controllers
Mado et al. (2022) Accessibility of Educational Virtual Reality for Children During the COVID-19 Pandemic [16]	411	Surveys	Large sample and longitudinal surveys on VR usage and the role VR plays in participant's life	Questionnaire and interviews about discomfort, fears, and adverse side effects	Authors did not conduct any experimental studies
Atzori et al. (2022) An exploratory study on the effectiveness of virtual reality analgesia for children and adolescents with kidney diseases undergoing venipuncture [5]	82	Use of Snow World, an interactive world in an icy tundra	Questionnaire based on scales for pain, fun, unpleasantness, and nausea	Values provided for immersiveness and adverse side effects (nausea)	HMZ T-2 Helmet supported by a laptop
Ali et al. (2022) Virtual reality-based distraction for intravenous insertion-related distress in children: a study protocol for a randomised controlled trial [1]	80	Variety of VR games based on experience level (videos, interactive environments, etc.)	Distress, pain, and fear measured using the OSBD-R rating system.	Adverse side effects (dizziness, nausea, headache) were recorded in event log	Oculus Quest with controllers
Southgate et al. (2022) School students creating a virtual reality learning resource for children [21]	53	VR content creation and testing	Rubric measuring content mastery, problem solving, self-directed learning and more	Reports of adverse side effects (dizziness, motion sickness, etc.)	HMD or on-screen
Maloca et al. (2022) Feasibility and tolerability of ophthalmic virtual reality as a medical communication tool in children and young people [17]	165	Experience various simulations of medical procedures	Simulator Sickness Questionnaire, demographics and prior experience, and task reaction questionnaire	Simulator Sickness Questionnaire	HTC Vive connected to a laptop

Author (Year): Title[Reference Number]	Participants	Task	Outcome Measures and Instruments	Cybersickness Measure	VR Description
Aminabadi et al. (2022) Assessing the Different Levels of Virtual Reality That Influence Anxiety, Behavior, and Oral Health Status in Preschool Children: Randomized Controlled Clinical Trial[3]	60	VR instructional videos and cartoons	SCARED Questionnare designed to measure anxiety. Frankl Questionnaire designed to measure pleasentness.	Reports of simulation sickness, nausea, and eye strain	Head Mounted Display
Du et al. (2022) A digital intervention using virtual reality helmets to reduce dental anxiety of children under local anesthesia and primary teeth extraction: A randomized clinical trial[7]	128	Interactive VR immersive scenes	Questionnaire based on scales for pain, anxiety, and immersion.	Simulator Sickness Questionnaire. No significant adverse effects were experienced.	HTC Vive with noise-cancelling headphones and wireless ‘controllers
Björling et al. (2022) Exploring the Effect of a Nature-based Virtual Reality Environment on Stress in Adolescents [6]	31	Immersive VR environments	Pre and post activity questionnaires measuring engagement and emotional experience	Interviews indicating simulator sickness (nausea, dizziness, and headaches)	Oculus Go
Araiza-Alba et al. (2021) The potential of 360-degree virtual reality videos to teach water-safety skills to children [4]	182	360° VR water safety training video	Scales for simulator sickness, water safety knowledge, and engagement.	Child Simulator Sickness Questionnaire	Cardboard headset with ASUS ZenFon 2
Oh et al. (2021) Feasibility of full immersive virtual reality video game on balance and cybersickness of healthy adolescents [18]	13	Varying VR games based on background motion	Questionnaires to measure motion sickness, bodily discomfort, disorientation, and nausea	Virtual Reality Sickness Questionnaire and Simulator Sickness Questionnaire	Playstation VR with games that have moving or non-moving backgrounds

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