Usability of an Immersive Virtual Playground: Enjoyment, Authenticity, Effort and Cybersickness

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***Abstract*—Immersive virtual reality systems have the potential to provide users with an engaging and ecologically valid environment in which to practice motor and cognitive skills. The purpose of this study was to evaluate the usability of a virtual playground for three age groups (children, young adults, and older adults) who performed three tasks within an immersive virtual playground. All participants had an overall positive experiences and minimal cybersickness while playing in the virtual playground although there were some key differences between them.**

Keywords—Immersive VR, effort, enjoyment, side effects, age

I. INTRODUCTION

Virtual reality (VR) refers to advanced computer technology systems that create dynamic, multi-sensory, simulated environments that enable users to perceive, explore and interact with simulated objects, scenarios and/or activities in real-time [1,2]. VR-based intervention has been shown to be more motivating than conventional therapy, lending itself to greater treatment compliance and prolonged engagement during treatment sessions [3].

Immersive VR systems isolate users from the physical surroundings by enveloping them within virtually generated visual, auditory and/or other types of sensory input which compete with real-world sensory input [4], often by means of a Head-mounted display (HMD. The use of such technologies as an adjunct to conventional therapy is appealing as a means of engaging clients in forms of therapeutic interaction that are inherently motivating, easily adaptable to the individual's needs and encourages increased compliance during therapy. A variety of VR technologies have been used but there has been some hesitation to employ HMDs due to their potential detraction from a positive user experience resulting from encumbrance and/or "cybersickness". The aim of this study was to characterize key aspects of user experience (i.e., perceived enjoyment, authenticity, effort, cybersickness) of participants from three age groups (children, young adults, and older adults) in a novel virtual playground as viewed via the VIVE, a readily available and relatively inexpensive HMD.

II. METHODS

A. Participants

Participants were obtained through a convenience sample of typically developing children and adult students and staff from a university setting. These included 15 (9 boys, 5 girls) children aged 6-10 years, 15 young adults (14 women, 1 man) aged 19-36 years, and 10 older adults aged 50-75 years (7 women, 3 men). There was no evidence of any neuromuscular pathology. Approval for the study was obtained from the University of Haifa's Committee for Ethical Research.

B. Instruments

1) VR Hardware

To view the VR system, an HTC VIVE HMD (vive.com) was used. Its physical size is 12x12x19cm and its mass is 470 grams. An integrated tracking system and an external tracking controller allows a VE to identify the user's exact location. In addition, the Leap motion sensor (leapmotion.com) was mounted onto the front of the HMD to display a 3-D virtual rendition of the users' hands in response to their actual hand movements.

2) Senserum virtual playground (senserum.com)

This is a 3D, highly graphically realistic environment depicting a children's playground including typical sights, sounds and objects. The user views the virtual playground in "first person" via the HMD, and navigates and interacts with virtual objects. It was designed and developed by Senserum together with Sensorynoa, occupational therapists that aim to provide sensory integration therapy to children with autism and other sensory processing disorders, but is also suitable for use with other therapies and children with other physical and cognitive impairments.

Three of the virtual plaground activities were tested in the current study: virtual seesaw, activated when users squat up and down (Fig. 1, left), virtual trampoline, activated when users jump to hit balls with their heads (middle), and virtual balloon game, activated when users hit colored balloons (right). Realistic visual and auditory feedback were provided during each activity.

Funded by the LINKS Israel Center for Research Excellence to Author PLW.

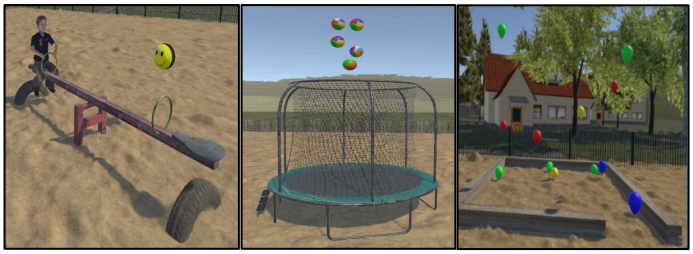

Fig. 1. Screenshots of three virtual playground activities: virtual seesaw (left), virtual trampoline and virtual balloon game (right)

3) Questionnaires

- Demographics. Demographics Questionnaire: General information about the participants, such as age, gender, gaming habits, tendency to have motion sickness were obtained.
- Short Feedback Questionnaire (SFQ): Three of the seven items from this questionnaire query the participant's subjective rating of task enjoyment, task effort and authenticity for each virtual task **(**SFQ-Adult*) [5], (*SFQ-Child*) [6]*. Each item is rated on a 5-point scale (e.g., 1=not at all and 5=very much).
- Adapted Cybersickness Question: A single question based on Keshavarz & Hecht's [7] tool to document cybersickness type symptoms following exposure to VEs and also adapted for children by using a 5-point pictorial (smiley) display, ranging from '1' (I feel fine) to '5' (I don't feel well, I feel nauseous).

C. Procedure

After familiarization with the tasks, participants performed each of the three virtual playground activities for 60 s in a randomized order. Following each activity, the cybersickness question was asked and their ratings of their perceived enjoyment, effort and authenticity were recorded.

TABLE I. MEANS AND STANDARD DEVIATION VALUES FOR EACH VIRTUAL PLAYGROUND ACTIVITY ACROSS AGE GROUPS.

		Mean (SD)		
		Children	**Young Adults**	**Older Adults**
Virtual SeeSaw	*Enjoyment*	4.8 (0.3)	3.8 (0.9)	3.7 (1.1)
	Effort	4.3 (0.9)	3.8 (0.9)	4.5 (1.1)
	Authenticity	4.0 (1.2)	3.7 (0.8)	3.6 (1.3)
	Cybersickness	4.6 (0.6)	4.1 (0.9)	4.0 (1.2)
Virtual Trampoline	*Enjoyment*	4.6 (0.6)	4.1 (1.1)	4.2 (1.1)
	Effort	4.1 (0.1)	4.7 (0.6)	4.7 (0.7)
	Authenticity	3.7 (1.3)	3.7 (1.0)	3.4 (1.3)
	Cybersickness	4.5 (0.9)	4.2 (1.0)	4.7 (0.5)
Virtual Balloon Game	*Enjoyment*	4.8 (0.4)	4.2 (0.9)	4.6 (0.6)
	Effort	4.5 (0.9)	3.9 (1.0)	4.4 (0.7)
	Authenticity	4.3 (1.0)	3.8 (0.0)	3.5 (1.3)
	Cybersickness	5.0 (0.0)	4.7 (0.6)	4.9 (0.3)

III. RESULTS

The participants from all three age groups had an overall positive experiences while playing in the virtual playground although there were some key differences between them (Table 1). The children rated all three activities more enjoyable (mean ± SD = 4.6±.6 to 5.0 ± 0) than the young (3.8±.9 to 4.2±.9) and older (3.7±1.1 to 4.6±.6) adults but the differences were only significant for seesaw activity (p=.002) and for the balloon activity (p=.013) between children and young adults. In contrast, there were no significant age-dependent effects for authenticity, effort or cybersickness for any of the three activities.

IV. CONCLUSIONS

The results of the current usability testing demonstrate that this immersive environment is perceived as being highly acceptable to three groups of users of widely differing ages. Most importantly, it documents the ability to engage in physical tasks while wearing an HMD and interacting with virtual objects without cybersickness symptoms. These findings establish the potential of the Senserum virtual playground as a viable therapeutic option for children, and adults with motor and cognitive impairments.

ACKNOWLEDGMENTS

The authors thank Rana Abbas, Shulamit Bamberger, Ora Coehn, Naama Reichman, Naama Rubin, and Odelia Spiegel who helped with data collection and analysis. Author AH is grateful to the Azrieli Foundation for the award of an Azrieli Post-doctoral Fellowship.

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