Exploring Smell, Wind and Heat Stimuli in a Virtual Beach to Support Students' Wellbeing

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Students' mental wellbeing is important for their positive academic progress. A growing body of research shows that exposure to immersive virtual reality (VR) environments can have a positive impact on students' stress levels and overall mental wellbeing. My students and I have developed a VR set up (a proof of concept) using off-the-shelf components and a microcontroller board to further study smell, wind, and heat stimuli in VR to support student wellbeing. Eight participants tested our VR set up in a pilot test, where the main task was to look at a 360-degree video of a beach displayed on a VR headset and perceive simulated wind coming from a controlled fan, ocean breeze smell coming from an ultrasonic humidifier, and heat coming from a heater and a heated car seat cushion. Results from a presence questionnaire shown that participants felt involved in the virtual reality experience, and the simulated wind and heat was effective for supporting the virtual beach immersion.

CCS CONCEPTS • **Human-centered computing → User interface toolkits;** *User studies*

Additional Keywords and Phrases: Smell, Heat, Wind, Virtual reality, Wellbeing

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1 INTRODUCTION

It is known that positive student mental wellbeing is important for achieving academic success [1,5]. However, higher education students' mental health can be affected by likely stressful events such as experiencing the COVID-19 pandemic, transitioning from secondary to post-secondary education, dealing with academic pressure, and moving to another country as international students [5]. A growing body of research shows that exposure to immersive virtual reality (VR) environments can have a positive impact on students' stress levels and overall mental wellbeing [6,7,11].

This study aims at exploring smell, wind, and heat stimuli in VR to further investigate whether this multisensory set up positively supports student wellbeing. To do this, we developed a proof of concept using off-the-shelf components such as a fan, a humidifier, a household heater, and a heated car seat cushion to support multisensory VR immersion of a relaxing virtual beach.

2 RELATED WORK

[14] developed an immersive virtual tropical island with a beach to support relaxation techniques. A pilot test revealed that most participants evoked previous personal relaxing experiences of holidays and beaches. A participant suggested "to increase the heating in the room and/or a fan that creates a calm breeze in the room". This was a good motivation for developing our virtual beach proof of concept. A related study found out the usefulness of a virtual island for supporting positive mood change and relaxation [2]. [9] tested a 360 degree-video of a beach projected in a VR headset with the

objective of assisting people's relaxation and for stress relief. Results of electrodermal activity measured during the participants' VR testing was not significant, but the subjective perceived stress level measured before and after the VR session was highly significant. Although there are reported studies that include heat and wind stimuli in VR (e.g., [3,4,8]), little is known about integrating smell, heat, wind, and audiovisual stimuli for improving wellbeing in VR.

3 PILOT TEST

To test the idea of using smell, wind, and heat in VR for supporting wellbeing, my students and I developed a proof of concept consisting of an olfactory display that included a Honeywell™ HT900CTC 18 cm (7") TurboForce® fan, and a Honeywell Mini Mist™ ultrasonic humidifier. We filled out the water reservoir with water saturated with sea salt to simulate the smell of ocean breeze. We also used a For Living™ Portable Ceramic Space heater with thermostat (1500W) and an AutoTrends™ infra-red heated car seat cushion to provide the effect of a warm beach chair. The fan was controlled by an Arduino™ Uno microcontroller board through a solid-state relay (SSR). The Arduino board changed the fan speed randomly to simulate ocean breeze variations. Relaxing music and beach sound effects coming from a 360-degree beach video [17] was played through wireless WH-CH520 Sony™ headphones. Participants donned an EVO™ VR headset, which had a Google™ Pixel 7 cellphone inserted in it, showing the 360-degree beach video displayed in VR mode on the cellphone's Android operating system. Figure 1 shows the VR set up.

Figure 1. A participant testing the VR set up and the virtual beach shown on the cellphone inserted in the VR headset.

We conducted a between-subjects test with our multisensory VR system. Participants were not compensated in this study. Participants were recruited emailing Algoma University students. Eight participants (computer science students) agreed to participate in our pilot study (seven males and one female), with an age average of 21 years. Each participant sat down in front of the heater, the fan, and the humidifier. The participants' main task was to wear the VR headset and watch the 360-degree video of the beach for five minutes and listening to the music and beach sound effects played on the headphones. The players were also asked to slowly look in all directions, up and down in the virtual beach. After testing the system for five minutes, each participant filled out a post-test presence questionnaire [15,16] with seven-item Likert scales, obtained from [12]. We did not include the last two questions because they are related to haptics, which we did not include in the pilot test. Presence is an immersive VR effect defined by Witmer and Singer as the "subjective experience of being in one place or environment, even when one is physically situated in another" [16].

4 RESULTS

Interestingly, the Likert scales from the presence questionnaire related to sound (questions 21-22) scored the highest. It seems that the beach sounds and the music coming from the 360-degree video were relaxing and pleasant indeed. Regarding question thirteen ("How involved were you in the virtual environment experience?"), its Likert scale median was six out of seven. The median of question seven ("How much did your experiences in the virtual environment seem consistent with your real-world experiences?") was five out of seven, showing a good correlation with participants' previous beach experiences. The median of the Likert scales from the presence questionnaire are shown in Figure 2.

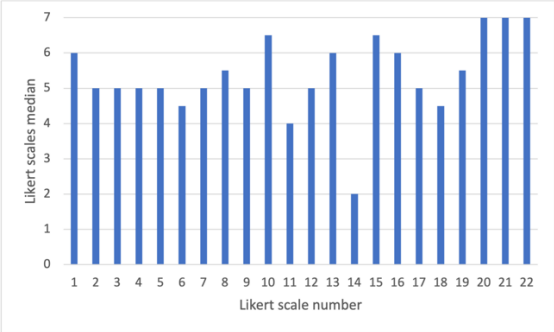

Figure 2. Median of the 22 Likert scales from the presence questionnaire [12] filled out in the pilot test.

Most of the participants perceived changes in the simulated wind coming from the fan, and they felt comfortable feeling the heat coming from the heater and the heated car seat cushion (which may be correlated to question thirteen). However, most of the participants did not perceive the smell of sea salt coming from the humidifier, despite working at maximum capacity. My students and I found that recreating the ocean smell is challenging. We tried using commercial essential oils marketed as "ocean breeze", but their smell was quite floral. We will try out the smell of coconut oil in further tests, to see if it can be better perceived and if it evokes participants being on a beach.

5 CONCLUSIONS AND OPPORTUNITIES FOR FUTURE RESEARCH

This study aimed at exploring smell, wind, and heat as multisensory stimuli in a virtual beach. This will be used to support students' wellbeing in further studies. We used low-cost, off-the-shelf components and a microcontroller board to set up a proof of concept. These components allowed rapid prototyping and collecting initial testing results. Most of the participants from our pilot test felt that the changes in the simulated wind coming from the fan and the heat were very effective for supporting VR immersion. Future research will be aimed to testing wind, heat, and smell stimuli under separate conditions and with a higher number of participants to get significant results, and to analyze how those stimuli will affect immersion in VR for assisting wellbeing. We will administer the World-Health Organization (WHO-5) questionnaire that measures users' subjective wellbeing [13]. Further developments that will support our research includes developing our own VR environment using the Unity™ game engine and developing our own smell diffuser using an ultrasonic transducer. We would like to conduct physiological measurements in further tests to obtain more accurate measurements of presence in our proposed VR system, to measure it the moment is experienced, as suggested by [10]. I wish to thank students from my Human-Computer Interaction course who participated in the VR setup and the students who tested it.

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