Human, Virtual Human, Bump! A Preliminary Study on Haptic Feedback

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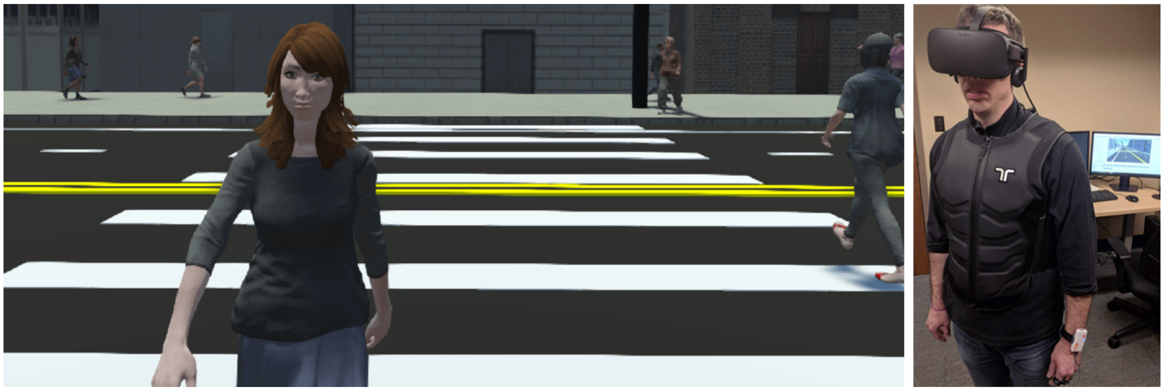

Figure 1: The virtual crosswalk environment (left) and the participant equipped with GSR sensor, haptic vest, and VR headset (right).

ABSTRACT

How does haptic feedback during a human-virtual human interaction affect emotional arousal in virtual reality? In this between-subjects study, we compare haptic feedback and no haptic feedback conditions in which a virtual human "bumps" into the participant in order to determine the influence of haptic feedback on emotional arousal, sense of presence, and embodiment in virtual reality, as well as compare self-report measures of emotional arousal to those objectively collected via event-related galvanic skin response (GSR) recordings. We plan to extend the current preliminary study by adding three more conditions as described in the future work section. Participants are students age 18-32 with at least moderate experience in virtual reality. Preliminary results indicate significant differences in presence and embodiment between haptic feedback and no haptic feedback groups. With our small sample size at the current time, GSR does not show significant differences between haptic and no haptic feedback conditions.

Index Terms: Human-centered computing—Human computer interaction (HCI)—Interaction paradigms—Virtual reality

1 INTRODUCTION

Virtual reality has high potential for psychosocial research [4]. Therefore, a better understanding of the influences and potentially required realism of haptics on emotional arousal and presence may aid in the creation of more believable human-virtual human interactions in virtual reality. Haptic feedback is present in many virtual reality games and experiences, but specific factors such as timing, intensity, and position accuracy remain underexplored. Furthermore, emotional arousal, which may or may not be associated with presence, appears lesser explored.

Previous studies have shown that haptic feedback in virtual reality can increase sense of presence. In the wobbly table study [2], participants who experienced slight movements of a physical table during their interaction with a virtual human experienced significantly higher self-report levels of presence than did those who felt no physical movements of the table. Additionally, Ryge et al. [3] found that higher fidelity haptic feedback felt from baseballs in virtual reality increased the perceived realism of the baseball. But how might haptic feedback influence emotional arousal, and how does more realistic haptic feedback compare to illogical or inaccurate haptic feedback? This study seeks to link emotional arousal recorded objectively via galvanic skin response (GSR) with subjective self-report emotional arousal, presence, and embodiment.

2 METHODOLOGY

Upon arriving, participants are briefly introduced to the project, and the purpose of the equipment as well as the experimental procedure are explained. While the participant completes a pre-questionnaire (concerning sex, age, and prior VR experience), the experimenter adjusts the self-avatar to most closely match the participant's skin tone, as we wanted to provide participants with a higher body ownership experience [8]. Then, the participant is fitted with the bHaptics "Tactsuit," a haptic gaming vest which allows precise control of haptic feedback, and is controlled with a Unity3D plugin. Next, a Shimmer GSR sensor is attached to the participant's non-dominant hand, with the two electrode sensors fit securely on the index and middle finger. The participant with all necessary equipment can be seen in Figure 1.

The participant is instructed to relax, try not to talk or move, and breathe normally, as these are the recommended instructions for minimizing muscular artifacts [1] [7]. The sensors are connected to iMotions biometrics recording and analysis software via Bluetooth. Within iMotions, the screen output of the virtual reality scene is captured and observable by the experimenter throughout the study (see Figure 2). The experimenter uses a timer to verify that the 2-minute baseline recordings have been obtained, and then starts the VR scenario.

2.1 Event-Related GSR

Once the participant confirms that he or she feels comfortable and is ready to begin, he or she is instructed to relax for 2 minutes, while baseline GSR is recorded. After this 2-minute period, the experimenter starts the virtual reality scenario that consists of 2 phases: exploratory, and experimental. In the exploratory phase,

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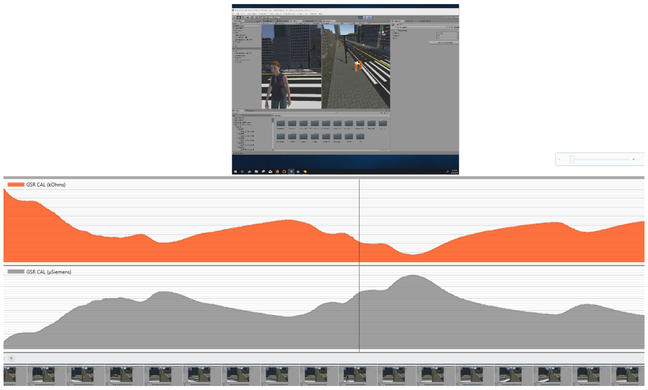

Figure 2: iMotions screen capture during experiment. The virtual environment in Unity3D (top) and the GSR data (bottom).

the participant is made aware of his or her self-avatar and virtual environment. In the experimental phase, the participant experiences one of the developed conditions.

2.2 VR Environment and Haptic Stimuli

For our experiment, all participants experience the same virtual environment during both phases: a busy crosswalk. The virtual environment was created in Autodesk 3ds Max and imported into the Unity3D game engine. Virtual humans were created in Adobe Fuse and animated with Mixamo. During the virtual scenario, virtual humans walk by on sidewalks, cross from behind the participant and walk towards the participant as they cross the street. Before haptic stimuli conditions commence, participants receive text instructions within the virtual environment that instruct them to "Feel free to look left, right and down at your body." In this 30-second exploratory phase, the participant sees his or her self-avatar, as well as sees virtual humans walking on sidewalks and crossing the street. Next, participants again receive text instructions to "Please face forward and remain still," in order to minimize movement artifacts in GSR signal.

During the next 2-minute period, participants are collided with, or "bumped into" by virtual humans. These collisions occur six times total for each participant, at 20-second intervals, as other virtual humans continue to pass by. Participants receive one of two conditions: haptic feedback or no haptic feedback. After the 2-minute experimental phase of the study, the virtual scene terminates. Participants then answer a post-experiment questionnaire to determine levels of presence, embodiment, and self-report emotional arousal. Our questionnaire is based on standard presence questions from the Slater-Usoh-Steed (SUS) questionnaire [6] and on standard questions concerning body-ownership illusion [5]. A comments section is provided at the end of the questionnaire for participants to express any additional thoughts.

3 Results

The current preliminary study examined two conditions: haptic versus no haptic feedback, with a sample size of eight thus far: four in the haptic feedback condition, and four in the control. A preliminary analysis of the presence and embodiment scores for these two groups looks promising, with a statistically significant difference seen between those who receive haptic feedback and those who receive no haptic feedback. For the results presented in this section, we have used a paired samples T-test. There was a significant difference in the embodiment scores for haptic feedback (M$= 4.03$, $SD = 0.61$) and no haptic feedback ($M = 1.94$, $SD = 0.52$) conditions; $t(3) = 35.34$, $p = 0.005$. Scores for presence also suggest a statistically significant difference for haptic feedback ($M = 5.31$, $SD = 0.85$) and no haptic feedback ($M = 3.31$, $SD = 0.52$) conditions; $t(3) = 8.0$, $p = 0.004$.

To analyze emotional arousal from event-related GSR, we looked at the 1-5 second time window immediately following the onset of the stimulus [1], in this case, the onset of virtual human collision, which occurs 6 times at 20-second intervals, starting at 161 seconds into the recording for every participant. For example, for the 161-second stimulus onset time, the time window 162-167 seconds was analyzed for the existence of GSR. While our current analytic approach involves simply "more" or "less" emotional arousal between participants in different conditions based on quantity of peaks, it may be interesting to consider GSR latency to onset of peak (the time is takes to reach the peak response), especially as the data from the more nuanced haptic feedback conditions (described in Section 4) is collected. Our results for event-related GSR indicate non-significance in this early stage of the study between haptic feedback ($M = 3.75$, $SD = 1.85$) and no haptic feedback ($M = 3.12$, $SD = 1.89$) conditions; $t(3) = 0.404$, $p = 0.713$. As we continue the study, an appropriate N may show significant differences in GSR between haptic feedback and no haptic feedback groups.

4 Conclusion and Next Steps

An overview of our experiment for investigating emotional arousal, presence and embodiment in haptic feedback and no haptic feedback conditions during human-virtual human interactions in virtual reality is presented. In this work, the methodology, technical set-up, as well as descriptions of the experimental procedure and specific virtual reality scene are presented.

As data collection continues, we plan to add the following conditions to the experiment: haptic feedback with inaccurate position (feeling the bump on the wrong side of the body: felt on the left side of the body, as the virtual human collides with the right side of the participant's body), haptic feedback with inaccurate intensity (50% increase from accurate haptic feedback), and haptic feedback with inaccurate timing (1 second delay between haptic feedback and human-virtual human collision). Preliminary data suggests a more engaging experience in virtual reality with the addition of haptic feedback, and paves the way for the continuation of our data collection and analysis concerning all five haptic feedback conditions.

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