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A Preliminary Study on the Effects of Virtual and Augmented Reality on the Psychological Response of Users when Hurting Avatars Depicting Friends and Strangers

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Abstract – In this study, we investigate how users respond when hurting an avatar depicting a friend in virtual and augmented reality. We perform a preliminary study where we ask participants to drop a heavy box onto avatars depicting strangers and a friend, and measured their response time, heart-rate, and subjective feeling of guilt. We found no significant effect on heart-rate and feeling of guilt, but found a significant difference in response times between avatar types in augmented reality.

Keywords : photo-realistic avatar, virtual reality, augmented reality, psychophysical response, moral dilemma

1 Introduction

With the advent of 3D scanning technology, it has become possible to perform 3D reconstructions of virtually anything, including humans. Body scanning systems, e.g. [1, 2], allow us to create a photo-realistic virtual copy of a person, which can be used by their owners as avatars in simulations, training, video games, or telepresence applications as a way to increase their immersion into the experience [3].

Meanwhile, virtual humans, i.e., virtual 3D models resembling humans, are increasingly being used in psychological research to study human behavior during social interactions. Studies have shown that virtual humans can evoke responses similar to those of human-human interactions [4, 5]. Indeed, virtual humans have been used to study human behavior in various situations, such as medical training [6], violence intervention [7], and moral dilemmas [8, 9]. These studies are usually conducted using immersive virtual reality (VR) and augmented reality (AR) systems, enabling researchers to design experiments that may be difficult, if not, impossible, to administer in real life due to safety or ethical concerns.

What if we replace the virtual humans used in psychological research with photo-realistic avatars depicting a person's friend? In this study, we investigate how people respond when hurting avatars depicting friends and strangers, and whether there are differences in VR and in AR. We conducted a preliminary experiment to see how users respond when dropping a heavy box onto avatars of strangers, as well as their friend, in terms of subjective feeling of guilt, heart-rate, and response time.

2 Related Work

Our work encompasses research areas related to photo-realistic avatars, and comparison between VR and AR in eliciting psychological response from users. We list some existing work in these areas below.

Some studies have investigated how users respond when interacting with photo-realistic avatars. Lucas et al. [3] investigated whether having users control an avatar that looks like them in a game affects performance and enjoyability when navigating a maze filled with mines. They found that male participants enjoyed piloting their own avatars more than female participants. They also did not care whether their avatar got hurt. Bouchard et al. [10] investigated whether people feel more empathy towards an avatar expressing pain when the avatar resembles a friend, and found that participants felt more sense of empathy and presence towards their friend's avatar. Our study builds on top of this study, specifically the idea of seeing a friend's avatar in pain.

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There have been studies that investigated the differences between VR and AR in terms of users' response when interacting with virtual avatars. Obaid et al. [11] investigated users' perception of coexistence with avatars in VR and AR environments, but found no significant difference in both conditions. Jo et al. [12] investigated how environment background (VR versus AR) and nature of avatar (reconstructed versus pre-built human model) affects users' sense of co-presence and level of trust with the avatar in a teleconference experience. Their results show that users felt greater sense of co-presence in AR, and more trust towards the reconstructed human model.

3 Methods

3.1 Research Questions and Hypotheses

For this study, we formulated the following research questions and their corresponding hypotheses:

How does the identity of the avatar affect the psychological response of the participants when hurting the avatar (**RQ1**)? We expect that hurting a friend, whether in real-life or virtually, will elicit a negative emotional response. Thus, we hypothesize that participants will exhibit more negative response when hurting the avatar of their friend (**H1**).

How does the platform (VR or AR) affect the participants' sense of presence with the avatar, and as a result, their response (**RQ2**)? We expect participants to be more immersed in the VR condition, and be more likely to perceive the avatar to belong in the environment. Thus, participants will experience greater sense of presence with the avatar in the VR environment, resulting in a greater negative response when hurting the avatars (**H2**).

How does gaming experience affect the participants' response (**RQ3**)? We expect participants who are frequent gamers to be more desensitized towards hurting people in video games. Thus, participants with less gaming experience will exhibit greater negative response when hurting the avatars (**H3**).

3.2 Experiment Scenario

Participants were seated in the middle of a room, and avatars appear in front of them one at a time. As soon as an avatar appears, they need to press a button as soon as possible, which makes a heavy box fall onto the avatar, causing the avatar to fall over. We used 5 different avatars, with each avatar appearing 12 times. 4 of the avatars were obtained from actual people that the participants don't know, while the remaining avatar is the friend's avatar.

3.3 Measures

At the start of the experiment, we recorded information about the participants such as their age, gender, gaming habits, and prior experience with VR/AR. We then considered whether empathy and immersive tendencies have an effect on the results, which we measured using the Toronto Empathy Questionnaire (TEQ) [13], and the Immersive Tendencies Questionnaire (ITQ) [14], respectively. At the end of each condition, participants rated their sense of presence with the avatar via the social presence questionnaire used in [15]. Finally, a post-experiment questionnaire (7-point Likert-scale type) was used to assess participants' enjoyment and feeling of guilt when dropping the box onto the avatars.

For physiological measures, we considered response time (time taken to press the button), to measure hesitation. We also utilized the heart-rate measurement tool by [16] in order to observe participants' anxiety levels throughout the experiment.

3.4 Participants

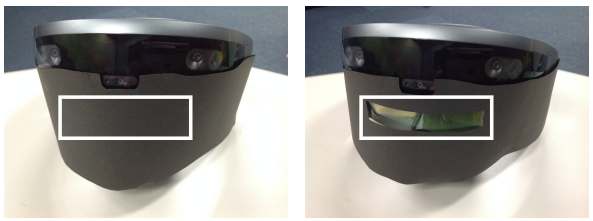
We recruited 5 pairs of participants for the study (3 male pairs, 1 female pair, and 1 mixed pair) who are of age 22 to 27 ($[25 \pm 1.56]$). However, due to problems encountered during the experiment, we had to exclude the results of 1 participant. The pairs were selected such that they are close friends with each other (non-intimate), have known each other for at least a year, and meet each other weekly.

3.5 Experiment Design and Procedure

We incorporated a within-subjects experiment design, with platform (VR, AR) as the within-subject factor. Participants were randomly assigned to first start with either the VR or the AR condition. In the AR condition, the avatars and the virtual box are superimposed into the real environment, while in the VR condition, everything is placed in a virtual room that has the same layout as the experiment room (Fig. 1). For both conditions, we used the Microsoft Hololens to render the virtual content. Since the Hololens is an optical see-through head-mounted display, we attached a custom-mask to occlude the participant's view of the real world for the VR condition (Fig. 2). To ensure similar field of view for both conditions, a mask was made for the AR condition to only show the area augmented by the display.

(a) VR (b) AR

Fig. 1: User's view in VR (a) and in AR (b).



(a) VR (b) AR

Fig. 2: Masks for VR (a) and AR (b) condition.

The experiment started with a briefing session, wherein participants were told a cover-up story to hide the real nature of the experiment. After gaining the pair's consent, one had their body scanned, while the other answered a pre-experiment questionnaire. They switched places after. We used an iPad with an Occipital Structure depth camera, along with the itSeez3d app, to acquire the participants' 3D models. We used the system developed by [17] to add a skeleton rig to the 3D model. Participants were then asked to come back on the next day for the actual experiment, this time, individually.

Participants were first given an explanation on how to use the Microsoft Hololens. They were then equipped with the heart-rate measuring device, and were asked to sit in the designated spot. A one-minute rest period was given to stabilize their heart rate. After completing the first condition, participants were asked to come back 2 days after for the second condition. After finishing both conditions, the participants were then asked to fill a post-experiment questionnaire. A debriefing session followed, wherein the real goal of the experiment was revealed. No participant expressed discontent towards the deception. They were then asked for free-form feedback about the experiment. Finally, they were given 1000 JPY (around 10 USD) as compensation for their time.

4 Results and Discussion

Table 1 shows the mean scores of the social presence questionnaire in both VR and AR conditions. A one-way ANOVA test revealed no significant difference in sense of presence with avatar ($F_{1,8} = 2.571, p = 0.147$) between both conditions.

Table 1: Social presence questionnaire scores.

Question	Mean (VR)	Mean (AR)
Sense of presence with avatar	4.22±1.31	3.22±2.10
Perception of avatar being not a real person	5.44±0.83	4.56±1.95
Perception of avatar appearing sentient, conscious, and alive	2.78±1.47	2.78±1.31
Perception of avatar being only a computerized image	5.33±1.15	5.78±1.03

We then look at the response times of participants for both conditions and for both avatar types. In the VR condition, the mean response time for the avatar of strangers and the friend is 0.5935 ± 0.0711 and 0.5901 ± 0.0632 seconds, respectively, while in the AR condition, it is 0.5862 ± 0.0804 and 0.6348 ± 0.1111 seconds, respectively. Two-way ANOVA revealed no interaction between condition and response time ($F_{1,8} = 0.899, p = 0.371$), but revealed an interaction between avatar type and response time ($F_{1,8} = 6.347, p = 0.0358$), particularly in the AR condition, wherein participants had higher response times when dropping the box onto their friend's avatar. Results from t-tests revealed no significant difference between response time of frequent and casual/non-gamers for both stranger ($t = 0.106, p = 0.9206$) and friend ($t = -0.394, p = 0.7139$) avatars in AR.

Observations from the heart-rate measurements revealed a general trend wherein participants experienced an increase in heart-rate upon seeing their friend's avatar for the first time, but remains stable for the remainder of the experiment. Participants were most likely surprised the first time they see their friend's avatar, but then realized that the consequences of their actions were not so bad, and thus they got used to it as the experiment goes on.

Results from the post-experiment questionnaire revealed no significant difference in terms of feeling of guilt for both avatars. In fact, all participants gave

the same score for both avatars (mean score: 2.3±1). This also implies no difference between frequent and casual/non-gamers in subjective feelings of guilt.

Finally, post-experiment interviews were also conducted to gather feedback from the participants. In general, participants found the act of dropping a box onto the avatars to be comical. The avatars also did not look realistic enough for them to believe the scenario. Finally, they were more focused on completing the task than being engaged in the experience.

5 Conclusion

In this study, we investigated users' response when hurting avatars depicting friends or strangers, and whether there is a difference in VR and in AR. While there was no effect in feeling of guilt and heart-rate, we found a difference in reaction times between avatar types in AR. However, response time can be affected by different factors such as individual skill and mental state. Thus, further investigation is necessary to verify the cause of the difference in reaction times.

In the future, we plan to design a full-fledged experiment that provides a more engaging experience to the participants. We also plan to consider other body scanning solutions in order to obtain higher quality 3D models of the participants. We are also considering using a more powerful HMD in order to render the avatars more realistically. Finally, we also plan to incorporate other physiological measures, e.g. galvanic skin response and pupil dilation.

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