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An Immersive Virtual Reality: The Effect of Haptics on Agency in a Virtual Environment

Rationale

Much research has been conducted regarding the ownership illusion over an alien appendage. The rubber hand illusion is a well-known example. In this experiment a rubber replica of a test subjects hand was placed in front of the subject in a life-like position while the subject's real hand was hidden. Researchers measured how the subject responded to simultaneously tactile stimulation of their hand and the rubber hand. The results showed that the users created a sense of agency over the rubber hand and reacted as if it was their own hand when the hand was threatened (Botvinick & Cohen, 1998). This is significant because it leads the way to a whole new psychophysical area of study concerning the basis of bodily self-identification.

Since the advent of immersive virtual reality, the inquiry into this agency illusion has gained much more traction. It is now possible to model a person or their body part in a virtual environment and determine how they respond. Studies have been conducted detailing how various feats of virtual reality can be manipulated to further create an illusion. For example, Argelaguet et al. (2016) researched how the realistic look of a user's hand in virtual reality can affect that user's ownership and agency in a virtual setting. Further studies have altered the skin color (Kilteni et al, 2013), shape of a person's body (Priyankova et al., 2014), or even number of fingers on a hand (Hoyet et al. 2016) in virtual reality and measured the user's response to such alterations.

In addition to self-perceptual studies in virtual reality, haptics is becoming a larger research area. After it was discovered that hands could be modeled in virtual reality, researchers started conducting experiments to determine how the user responds to a virtual environment that is haptically different from the physical environment. This sort of study in psuedohaptics manipulates what the user is feeling in real life and what it looks like they are feeling in virtual reality to determine how much the virtual environment can be altered until the user does not think they are in a virtual environment. An example is Lecuyer et al. (2000) experiment using a Spaceball device to simulate the compression of the spring, while the user was shown a differing view of how much the spring was being compressed. It was determined that the visual feedback given to the user created an illusion that the spring took a different amount of force to compress than it actually did. This haptic disconnect hints at the potential to which virtual reality can manipulate proprioception.

The research conducted in this experiment combines the advances in ownership illusion with haptic feedback to determine if a user's agency over a virtual hand can vary depending on the haptic feedback they receive.

Research Question/Hypothesis/Expected Outcomes

How does haptic feedback effect one's sense of agency in virtual reality? It was hypothesized that the more one feels with their hands in the real world while immersed in virtual environment, the less they will associate the virtual representation of hands to actually being theirs.

Many researchers have shown some counterintuitive results in regards to agency and virtual representation. Argelaguet et al. (2016) determined that the more like a real hand the virtual representation looks, the less agency a person feels because the hand has a larger chance of acting imprecisely.

In addition, many haptics studies observed psuedohaptic feedback to effectively being able to cause a false impression, indicating that a visual stimulus usually outweighs haptic feedback. Ban et al. using a viseo-haptic system, determined when a user touches an object that has horizontal edges different from the angled edges shown on the screen displaying their hands, most of the users believed that the actual object's edges had some angles like the one shown on the screen.

A combination of the idea that the realism decreases agency and haptics can be illusory support a hypothesis for this experiment that if the user can feel an object that they are seeing on the screen with their own hands in real life as well, their agency of the hands on the screen would be less.

Procedure

A simple virtual environment was created using UnrealEngine4 in which the user is place in a first person perspective in front of three blocks. An oculus rift with an attached Leapmotion sensor was used to provide an immersive environment in which the users can see their hands in virtual reality. This experiment consisted of two different tasks. In the first task the user was told to lift a virtual block. In the second task, the user was told to lift a virtual block while an exact replica was in its location in the real world. In this experiment 3 random test subjects at an age of 19, with no previous experience in virtual reality were placed a virtual environment in which there were three blocks in front of them. An oculus rift and an attached leap motion sensor was used to simulate an immersive virtual environment that was created in UnrealEngine4. Initially the test subjects were allowed to move their hands around in virtual reality and look around to experience how the tracking works. This control run, allowed the user to feel what an immersive virtual environment with their hands being tracked felt like, before assessing the agency of their hands while doing tasks. After each participant had completed the first task of feeling and lifting virtual block and the second task of feeling and lifting a virtual block and a real block in front of them, they were given a short questionnaire. The questionnaire consisted of 5 questions rated on a 7-point Likert scale. The questions were made as specific as possible to the situation the participants were immersed in, and was used to determine the agency the user felt over their hand.

Human Participant Research

No particular age range, gender or racial/ethnic composition were sought for this experiment. In addition, vulnerable populations such as those with sever vision or mental problems were avoided in this research. The subjects were used simply to complete two tasks and take a questionnaire, taking no

It felt like I was actually holding something when I was holding the virtual block.
I expected the virtual representation of my hand to act in the same was as my actual hand.
When rotating the virtual block did It felt like I was rotating a real block.
Using the virtual representation of my hands to move blocks in virtual reality felt comfortable.
The size of the virtual block felt similar to a real one.
The shape of the virtual block felt similar to a real one.

longer than 10 minutes to complete. Not much personal data needs to be collected for this experiment besides name, age, and past experience with virtual reality. This information will be entered anonymously into a blank document which with then be compiled and saved in an Excel spreadsheet, with the other data collected throughout the experiment. This data will not be accessible by anyone else besides the one conducting the research and will be deleted after the study. The participants will be informed of just the tasks they are required to do before their participation in order to prevent any form of cognitive bias in their answers to the questionnaire. They will also be given a consent form to sign, detailing

Risk and Safety

Virtual Reality has developed far enough to the point where practically anyone can use a Head Mount Display (HMD) safely. None of the equipment that the subjects were using or tasks that they were asked to do posed a risk to their safety or health. Most researchers conclude that and Virtual Reality-Induced Symptoms and Effects (VRISE) are short lived and minor (Cobbs et al., 1999), (Nichols & Patel, 2002). Many researchers believe that that virtual reality can even be beneficial to health in psychological therapy (Schuemie, 2001), like for treating PTSD by creating controllable situations and enhancing emotional engagement (Botella et al., 2015).

In this research experiment, the risk of any VRISE was minimized. The users were allowed to take a break or stop altogether using the headset if they felt discomfort in anyway. Before beginning the users, comfort was assured and during the experiment it was verbally reassured. If the user did need a break, it would not affect the collection of data in the experiment because there was no ongoing measurement of agency nor was the subjects task timed, only a questionnaire was given afterwards. In addition, the Oculus Rift HMD was used, which Chessa et al. in 2016 determined to have a strong effect on immersing a user into a virtual environment while avoiding negative VRISEs like simulator sickness and anxiety, in comparison to other HMDs. The research done by Chessa et al. explicitly suggests that the Oculus rift is a safe and powerful tool to use in research and in clinical applications.

Data Analysis

The data collected will be plotted and the mean of the responses will be determined. The questions were worded so that a higher numbered response would indicate a larger sense of agency, making it easy to compare the mean values for the agency each participant felt in each task. In addition to this statistical analysis, each participant's response to each question will be graphed on a 2 different cluster bar charts (1 for each task) and visually analyzed to determine the overall trend in agency between the two tasks.

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Project Summary

No changes made to the original research plan