Effect of Vestibular Motion on VR Engagement

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Abstract

Human perception involves interpreting many sensory inputs to determine the context of their experience. In the realm of Virtual Reality, the system is in charge of providing specific sensory information to the users to embed them into a digital landscape. We use a combination of senses, including vestibular balance to determine spatial orientation and position within our environment. The discrepancy between the visuals provided by VR and our vestibular orientation in the natural world may cause motion sickness and disengage users. We are investigating the application of vestibular approaches to VR experiences and more specifically how engaged the person feels in the virtual environment. The experiment we propose would have a set of users taking part in a simulated environment where they would be in control of moving their head to view what is around them. In the first setup, the head motions by the user would result in the background moving proportionally to the user's head movements resulting in a vestibular match. In the second case, we would introduce some form of lateral movement, which the user cannot control through head movements. This would result in a vestibular mismatch. We hypothesize that when a user experiences a greater match in vestibular motion, the user would be more engaged in the video game and have a greater presence.

INTRODUCTION

Human perception involves interpreting many sensory inputs to determine the context of their experience. In the realm of Virtual Reality, the system is in charge of providing specific sensory information to the users to embed them into a digital landscape. We use a combination of senses, including vestibular matching to determine spatial orientation and position in our environment. Any discrepancy between the visuals provided by virtual reality systems and our vestibular orientation in the natural world, may cause motion sickness and disengage users from the digital experience. We are investigating the application of vestibular approaches to VR experiences and more specifically how engaged the person feels in the virtual environment.

We want to determine if users are more prone to motion sickness if motion in game does not match their vestibular senses. Motion sickness would lead to users being less engaged and having a lower presence in games. Even if the users don't experience kinetosis, we plan to determine the degree of motion correlation required to maintain user interest and provide a sense of realism in the virtual reality system.

EXPERIMENT

Goals and design:

The experiment is intended to determine if users are more prone to motion sickness or discomfort if in-game motion does not match their vestibular senses. In order to test how a vestibular mismatch affects a ***user's engagement*** and ***simulator sickness*** in a videogame, we propose a two stage experiment. In the first stage users would be operating in a system that mimics their head motion and field of view. They would be able to look around using head movements and observe their environment, with minimal latency to their actual visual perspective. In the second case, users would additionally be subjected to some external perceived motion, thus causing a vestibular mismatch. This can be simulated by providing a walking or driving simulation that doesn't change perspective when users turn their heads. All they perceive would be the motion of the world around them, as if their head was stationary through a static vantage point. The experiment would be conducted within participants, i.e., all participants are exposed to both stages. A questionnaire is provided to the participants at the end of each stage to gauge their level of engagement and presence in the video game.

Hypothesis:

We hypothesize that users would be more engaged and less motion sick when there is a vestibular match as in the first stage of the experiment. When there is some mismatch between in-game visuals and the actual vestibular senses, it results in a vestibular mismatch and hence would reduce the engagement and induce sickness to the user.

METHODS

Participants:

A total of 12 participants (7 male, 5 female) from the User Experience class took part in the experiment. All the participants were in the age group 20-30 and of higher technical background.

Apparatus and Stimuli:

An environment from Epic Games would be used and setup in the Visual Experience Lab at North Carolina State University. A tracked VR headset would be connected to a PC with a GPU embedded in it. The headset would provide the VR experience to the participants. After participants operate in the VR environment, we plan to capture their responses to our surveys in Google Forms.

Procedure:

The participants would be given a brief introduction about the experiment and detailed instructions on how to play the game and use the VR headset. They would be allowed to get used to the environment for a short duration before we begin the experiment. The participants would also be given time to ask queries, if any.

We plan to utilize the Simulator Sickness Factors and the Game Engagement questionnaires to record participant responses. The sample topics listed in each survey highlight the features we plan to investigate by changing the vestibular presence to determine user engagement and perceived sickness.

Simulator Sickness Factors:

Participants are asked to respond with a number from 0 to 3 to indicate the severity of the symptoms (0 being absence of the symptom and 3 being severe) they experienced during the experiment. The symptoms include general discomfort, fatigue, headache, eyestrain, difficulty focusing, sweating, nausea, difficulty concentrating, blurred vision, dizziness with open/closed eyes, vertigo, stomach awareness and burping.

Game engagement survey: Participants are asked to respond with a number from 1 - 4 depending on whether they strongly disagree with the question (1) or strongly agree (4).

1. When I was playing the game I lost track of the world around me
2. I blocked out things around me when I was playing the game.
3. The time I spent playing the game just slipped away.
4. I was absorbed in my gaming task.
5. I was so involved in my gaming task I lost track of time.
6. During this gaming experience I let myself go.
7. I lost myself in this gaming experience.
8. I was really drawn into my gaming task.

9. The gaming experience was demanding.
10. The gaming experience did not work out the way I expected it to.
11. I would recommend playing the game to my friends and family.
12. My gaming experience was rewarding.
13. My gaming experience was fun.

RESULTS

Survey Analysis:

In order to aggregate participant responses, the mean values of their responses were generated per question in both the simulator sickness survey and the game engagement survey. For the Sickness Survey, the aggregate scores from the vestibular match totaled 11.667 out of a maximum 48 possible points while vestibular mismatch had a significantly larger total of 19.916. The range of values for the game engagement survey had much smaller difference between the two phases of experimentation. Website specific questions from the game engagement survey proposed by Wiebe et al. were disregarded for the current context, which produced the following results. The vestibular match phase had a total score of 31.500 out of 42 possible marks with the vestibular mismatch summation coming just short with a total of 29.833. Below figure 1 shows this previously described comparison. Delineated results by question can be found as Figure 2 & 3 in the Appendix.

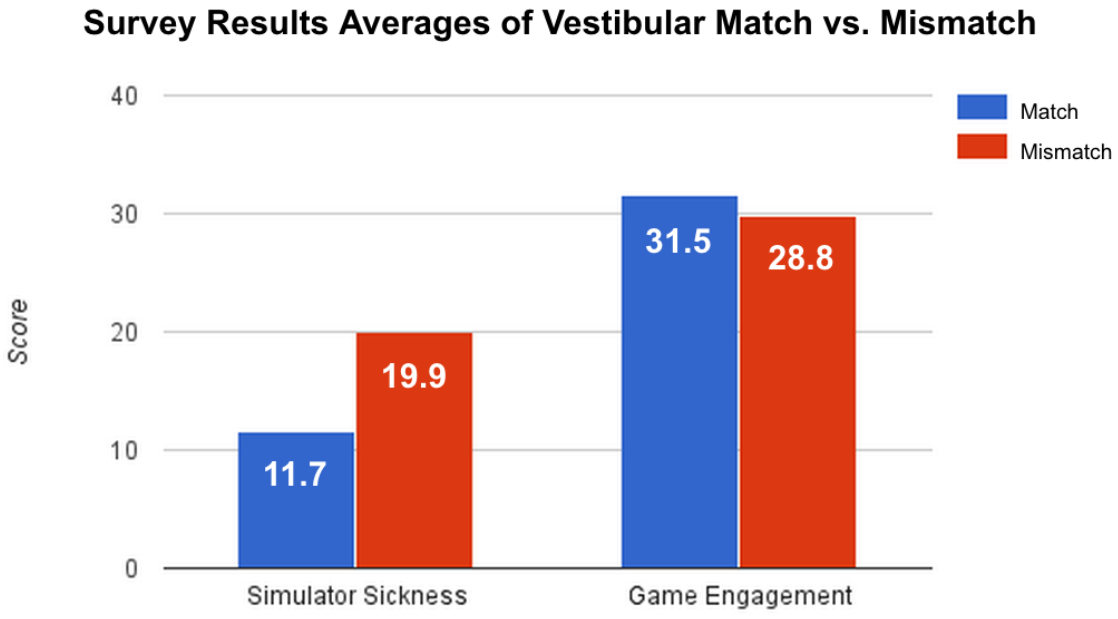

Figure 1.

CONCLUSION & EXPOUNDING REMARKS

As results indicate, there is a perceived sickness and lower engagement in the case of vestibular mismatch. Confirming our hypothesis that when a system closely matches a user's vestibular response to motion, then they have less discomfort and a greater sense of engagement. For this discovery, we propose few remarks for the developers to provide an overall better gaming experience. The developers should understand the effect of content loading on the users, and try to achieve low latency and high framerate to provide seamless gameplay. Studies show that even expert users tend to experience simulator sickness when exposed to the VR environment for long time. Therefore, restricting per session gameplay time or adding objective checkpoints to the game can spread out the effect of longer exposure to the VR environment and allow content to load without overusing the systems computing resources. Further enhancements include limiting the uncontrolled /rapid motion in the game, which can reduce mismatch between the senses thus resulting in a pleasant experience. VR gaming is an emerging technology and extensive research being done in the field, which means that a majority of the population are unexposed to the VR environment. These inexperienced users can lend a lot of insight into developing games for all audiences. Specifically playtesting the game with different user experience levels can prove crucial to ensure that the game presents the features as seamlessly as the developer intends.

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APPENDIX

Figure 2:

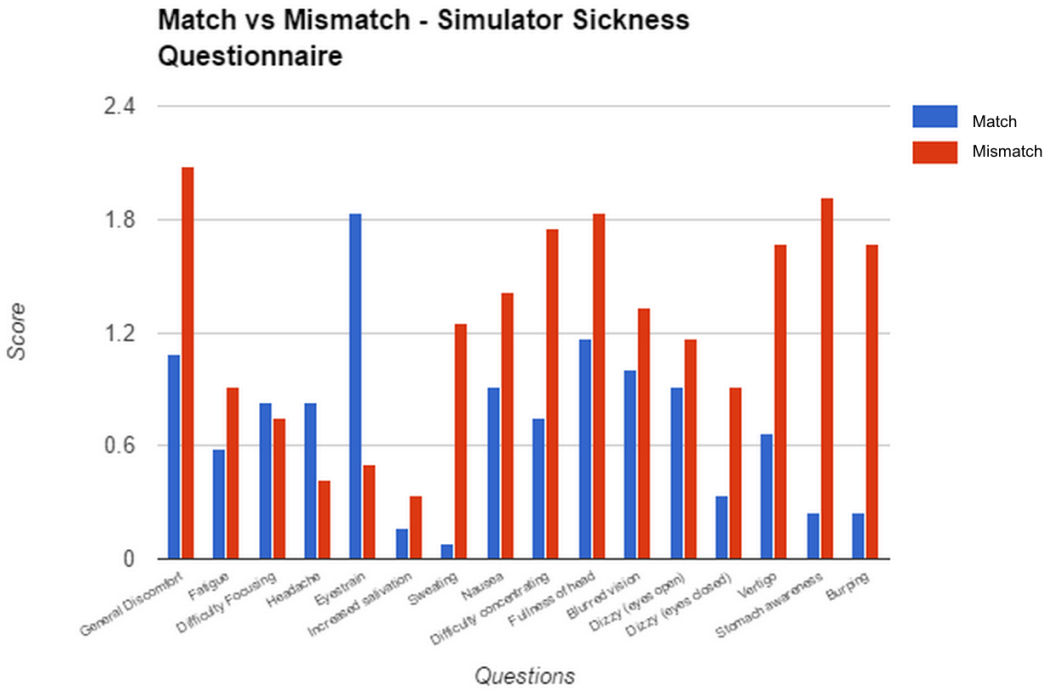
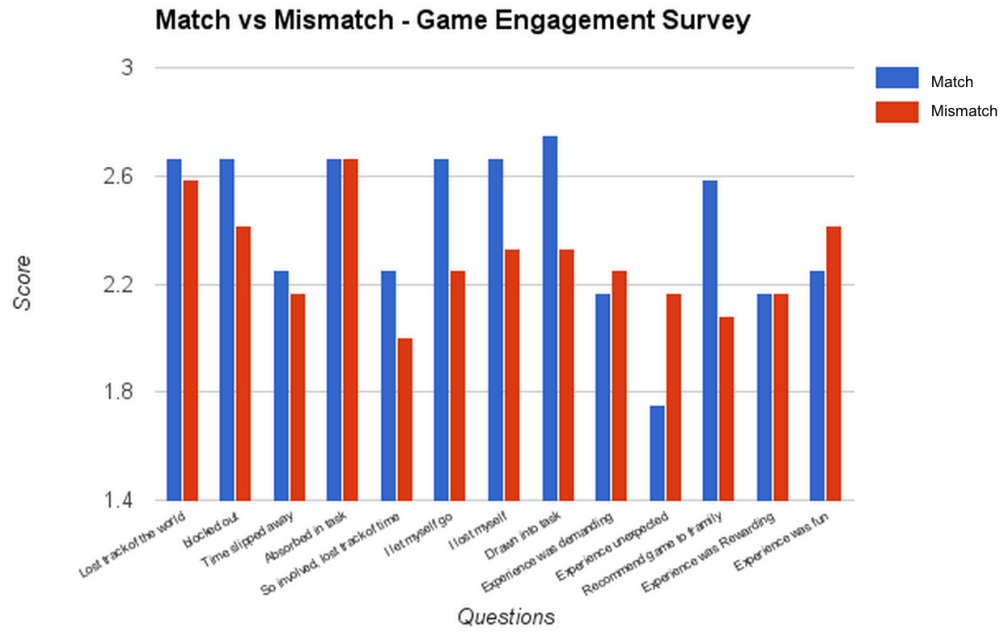


Figure 3:


Match vs Mismatch - Game Engagement Survey
3
2.6
2.2
1.8
1.4
Score
Match
Mismatch
Lost track of the world
blocked out
Time slipped away
Absorbed in task
So involved, lost track of time
I let myself go
I lost myself
Drawn into task
Experience was demanding
Experience unexpected
Recommend game to family
Experience was Rewarding
Experience was fun
Questions