The Effect of Body-Based Haptic Feedback on Player Experience during VR Gaming

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Abstract. As the interest in virtual reality (VR) technology as a game console has rapidly grown over the past few years, many new technologies are also being developed to further enhance the VR gaming experience. One of these technologies is haptic feedback vests, which are beginning to hit the market with claims of elevating the player experience (PX). Since the use of haptic vests during gameplay is still in its early stages, their influence on the PX during VR gaming is understudied. Accordingly, the current study investigated the effect of providing body-based haptic feedback on players' sense of presence and overall PX during VR gaming. Participants played a VR-based rhythm game both with and without a haptic feedback vest and provided self-reported ratings of their sense of presence and PX. Results revealed that there was no significant difference between playing with a haptic vest and without a haptic vest in terms of players' sense of presence and PX during the gameplay. As a whole, these results indicate that providing body-based haptic feedback using a haptic vest may not always increase sense of presence and PX levels when playing a rhythm game in VR.

Keywords: VR gaming, Haptics, Haptic feedback, Haptic Vest, Player Experience.

1 INTRODUCTION

Innovation is key when it comes to a user's experience in gaming. Often the most successful ideas are the most inventive and create new opportunities for developers. Virtual reality (VR) has opened new possibilities in the realm of gaming, giving users a new way to immerse themselves in the game world. While VR can be used in other areas, the game industry has arguably seen the biggest impact, as evidenced by the increasing number of VR-compatible video games on Steam, a popular game distribution platform [1]. Along with VR, however, other technologies, such as haptic vests and gloves, have been developed to help enhance the gaming experience even further. The goal of these technologies is to provide players with a greater connection to the game world, which is, in turn, purported to enhance their player experience (PX).

VR involves the use of computer-generated imagery in a three-dimensional space that allows the user to interact with a simulation in a more natural way. These simulations are often referred to as virtual environments (VE). This interaction creates a more immersive feeling when done correctly by allowing the user to traverse through and interact with a VE in a way similar to which they would in the real world [2].

VR gaming continues to grow in popularity as new, more immersive headsets and technologies become available to consumers and as developers create new and innovative ways to play [2, 3]. One of the affordances of immersive gaming technologies is haptic feedback, which can be provided in the form of full-body feedback through a haptic vest and/or in the form of interactive feedback through the use of VR controllers. While the latter has received a great deal of interest from both academic researchers and practitioners [3], the former has been rather understudied. More specifically, little empirical data are available on how providing body-based haptic feedback through a haptic vest affects the PX while users are playing a video game in VR. To address this issue, we conducted a pilot user study in which participants played a VR-based rhythm game, Beat Saber, both with and without a haptic vest. Participants then provided self-reported ratings on their sense of presence and overall PX. Results revealed no statistically significant differences between the haptic vest and no-haptic vest conditions. These results indicate that providing body-based haptic feedback using a haptic vest did not lead to substantial increases in sense of presence and PX, which is a finding incongruent with our initial prediction.

The main contribution of our pilot study is a user study providing an empirical investigation into the effect of body-based haptic feedback through a haptic vest on VR gaming experience, which is an understudied area of research within the VR gaming literature. Thus, it is hoped the findings from the current study will provide an impetus for further research into this emerging domain. In the following sections, we provide a review of related work and a detailed description of our user study, along with the results and discussion.

2 RELATED WORK

2.1 Presence and Player Experience

Virtual reality has enhanced the immersive nature of video games leading to greater levels of presence. Witmer and Singer describe immersion as a psychological state in which oneself is enveloped by and views themselves as integrated with a VE that provides the user with continuous stimulation [8]. The intent of VR is to create an immersive experience for a user with the ideal outcome of achieving a high level of presence. Presence can be summarized as the experience of being in an environment, even though one is physically situated in another [5]. Presence can be measured through two self-observed factors. First, the player should be able to self-report their own level of presence in the game [6]. Additionally, the player should be able to experience a sense of being elsewhere during their gaming experience [6].

Presence and immersion are important elements to consider for game developers because they have a direct connection with the PX, which refers to the player's overall

experience with the game and is directly associated with their enjoyment of the game [7]. PX can be considered one of the most important factors contributing to a game's success. The reason is that most games are meant to either exist as a service in which they are playable for years after release, or simply excel to the status of critically acclaimed games. By allowing players to feel immersed and present in a VE, developers stand the chance of creating a great PX.

2.2 Haptic Feedback and Player Experience

The emergence of haptic vests is a relatively new concept in the gaming industry. Just as with VR headsets, haptic vests are starting to enter the consumer market, thus making it more accessible to a larger audience. While some haptic controllers have previously been available to consumers, recently technological improvements have allowed for haptic vests to be developed. The use of haptics can enhance the PX as it helps to provide tactile feedback based on in-game objects [7]. In fact, Kim et al. argue that without the use of haptic responses, VEs can result in a disconnect between the real world and a virtual world [8]. This means that the use of haptic feedback can breathe new life into VEs.

The utility of providing such body-based haptic feedback is to enhance the meaningful involvement of multiple senses during the gameplay, which can lead a greater sense of presence inside the VE. To the best of our knowledge, no empirical evidence is available on the effect of providing body-based haptic feedback through a haptic vest on PX during VR gaming. That said, it has already been shown that just the use of haptic controllers can increase a player's sense of presence [8, 9]. With this is mind, providing body-based haptic feedback using a haptic vest can potentially lead to a more immersive experience and further the level of presence experienced by the player while playing a game. Accordingly, the purpose of the current study was to investigate the effect of providing body-based haptic feedback on both sense of presence and PX during VR Gaming. The hypotheses of the current study were:

H1: Compared to no body-based haptic feedback, providing body-based haptic feedback would invoke a greater sense of presence in the VE.

H2: Compared to no body-based haptic feedback, providing body-based haptic feedback would lead to a greater PX.

3 METHOD

To test these hypotheses, we conducted an experiment in which participants played a VR game with and without body based haptic feedback. The independent variable was the existence of body-based haptic feedback (haptic vest vs. no haptic vest). The independent variable was manipulated within-subjects, so participants took part in both conditions. The dependent variables were the sense of presence, as measure by the Presence Scale, and PX, which was measured using the Game User Experience Satisfaction Scale (GUESS), as described below.

3.1 Participants

The participants in this study were recruited using an email announcement sent to the student population at the university where this study was conducted. In total there were 30 participants, with 18 females and 12 males. The average age of the participants was 21.1 (*SD* = 2.6).

3.2 Materials

Game User Experience Satisfaction Scale. The Game User Experience Satisfaction Scale (GUESS) is a multidimensional scale designed to measure a player's PX during the gameplay [10]. The GUESS has a total of 9 dimensions for the different facets of the PX. These include Usability/Playability, Narratives, Play Engrossment, Enjoyment, Creative Freedom, Audio Aesthetics, Personal Gratification, Social Connectivity, and Visual Aesthetics [10]. Since the game used in this study was a single player rhythm game, the Social connectivity and Narratives dimensions were excluded from the questionnaire presented to participants. Thus, the modified GUESS questionnaire included 44 of items corresponding to the remaining seven dimensions. A total GUESS score quantifying the PX was calculated for each participant in each condition. Greater GUESS scores indicate greater PX.

Presence Scale. The Presence scale is a self-reported measure focused on determining the level of sense of presence an individual experiences in a VE [5]. The presence scale includes a total of eight items rated on a 7-point Likert scale. A total presence is scored by averaging the responses to all items. A higher score on the presence scale indicates a player feeling a greater sense of presence during the gameplay.

Gaming Platform. We used the Oculus Rift CV1 (the Rift) headset for this study [11]. The Rift makes use of an HMD that tracks the user's head movement and position within a VE and includes both a gyroscope and accelerometer to replicate the user's head movement within the VE. The HMD also supports 1080 x 1200 resolution in each eye with each display having a refresh rate of 90 Hz and sporting a 110-degree field of view (FOV) [12, 13]. Participants also used the Oculus Touch controllers while playing the game.

Body-Based Haptic Feedback. To provide body-based haptic feedback during the VR gameplay, we used a haptic vest, specifically the Tactot vest and Tactosy arm sleeves by bHaptics [14] (Fig 1). The vest utilizes 40 different vibration points around the user's torso [14]. As for the arm sleeves, they include 6 vibration points for each arm [14]. These vibration points are designed to mimic sensation of touch. In the current study, the sensors were used to convert the rhythm of the sounds within the game into vibrations, mimicking the rhythm of the sound through body-based haptic feedback. Participants put on both the vest and arm sleeves in the haptic feedback condition.

Fig. 1. An image of Tactot vest for torso and Tactosy arm sleeves taken from https://www.bhaptics.com/tactsuit/ [14]

VR Game. This study used a popular VR-based rhythm game called Beat Saber [15]. Beat Saber is a rhythm game where the player must slash blocks as they pass in accordance with the rhythm of the song being played. The song that was used in this study was Country Roads (Sqeepo Remix) by Jaroslav Beck and Kings & Folk. Participants played this song on easy mode and the options for a no-fail mode and a no-obstacle mode were turned on.

Fig. 2. A screenshot of the Beat Saber game, taken from https://beatsaber.com/ [12].

3.3 Procedure

When participants first arrived, they were greeted and instructed to review the informed consent form. While the form was being completed the participant was assigned a random starting condition, which involved starting with or without the haptic vest. This was done due to the within-subjects manipulation of the independent variable in which participants were to participate in both the no-haptic feedback vs. haptic feedback conditions. Once the consent form was completed, the participant played the tutorial available within the game. After completing the tutorial, the participant played the song (meaning that they played the VR game while the song was being played in the background). Depending on their assigned starting condition, participants put on the haptic vest and arm sleeves as well. Upon the song's conclusion the participant was directed to the questionnaire containing the study measures. After the first completion of the first condition, participants took a short break between the conditions, while the experimenter prepared the next part of the experiment. After the break participants then completed the same song for the other condition. If they started out with the haptic feedback condition, then they did not put on the vest and arm sleeves in this second condition, and vice versa. Following the completion of the second condition, participants were directed to the questionnaire for a second round of measurements. At the end, participants were debriefed and afforded the opportunity to ask any questions. The entire experiment was completed in about 30 minutes.

4 Results

Before hypothesis testing, we explored the data from the experiment (see Table 1 for descriptive statistics) and checked for assumptions. The assumption of normality was not met for a paired samples *t* test. Therefore, the nonparametric alternative, Wilcoxon Signed Rank Test, was conducted instead (see Table 2 for inferential statistics).

Table 1. Descriptive Statistics for Dependent Variables.

	M (*SD*)	*Mdn*
Sense of Presence		
No Haptic Feedback	5.18 (1.56)	5.63
Haptic Feedback	4.99 (1.56)	5.13
Player Experience		
No Haptic Feedback	42.37 (3.43)	42.74
Haptic Feedback	42.75 (3.21)	41.92

M: mean, *SD*: standard deviation, *Mdn*: median

Table 2. Results of Hypothesis Testing.

	W	*Mdn*	M_{diff}	95% CI	*d*
Sense of Presence	208	.656	.125	[-.312, .625]	.125
Player Experience	154	.173	-.646	[-1.51, .290]	.146

Mdn: median, M_{diff} : mean difference, 95% CI: 95% confidence intervals, *d*: Cohen's d as effect size measure

A Wilcoxon signed rank was conducted to determine if there were differences in both presence scores and PX scores between the use of a haptic vest and no haptics. Results indicated that presence scores (Hypothesis 1) were not statistically significantly different between the no haptic feedback (*Mdn* = 5.63, *M* = 5.18, *SD* = 1.56) and haptic feedback conditions (*Mdn* = 5.13, *M* = 4.99, *SD* = 1.56), *W* = 208, *p* = .656, 95% CI [-.312, .625], Cohen's *d* = .125. Fig. 3 represents the presence level scores as a function of haptic feedback.

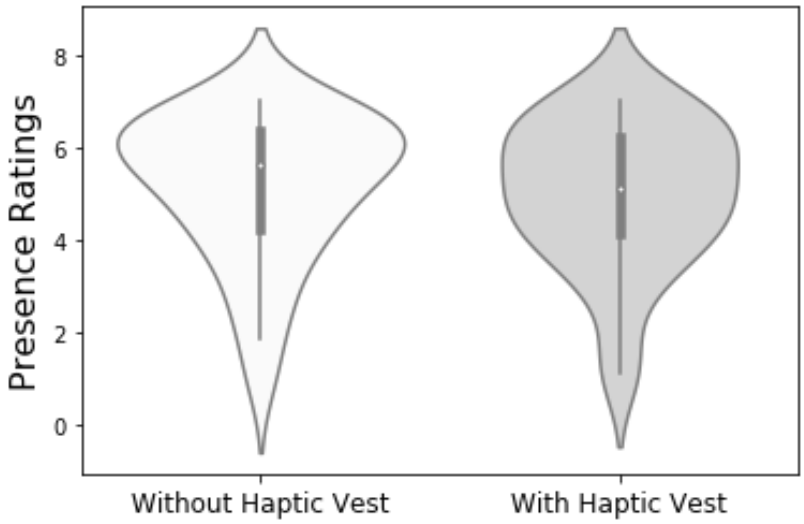

Fig. 3. Sense of presence levels. The violin plot displays the box plot for each condition along with the kernel density estimate for the distribution of scores in each condition.

As for the effect of haptic feedback on PX (Hypothesis 2), results revealed no statistically significantly differences between no haptic feedback (*Mdn* = 42.74, *M* = 42.37, *SD* = 3.43) and haptic feedback conditions (*Mdn* = 41.92, *M* = 42.75, *SD* = 3.21), *W* = 154, *p* = .173, 95% CI [-1.514, .290], *d* = -.146. Fig. 4 represents the PX scores as a function of haptic feedback.

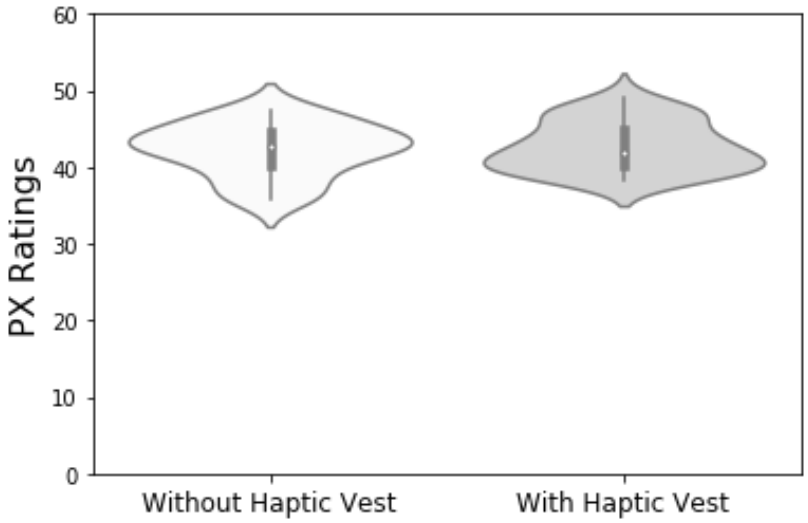

Fig. 4. PX ratings as a function of haptic feedback. The violin plot displays the box plot for each condition along with the kernel density estimate for the distribution of scores in each condition.

5 Discussion

The purpose of this study was to investigate the effect of body-based haptic feedback on sense of presence and PX levels during VR gaming. We hypothesized that providing body-based haptic feedback using a haptic vest would invoke a greater sense of presence and a more enjoyable overall player experience during VR gaming. Results indicated that there was no significant difference in sense of presence levels when gaming with and without the haptic vest. Similarly, the experiment yielded no significant differences in PX levels between the two conditions. Therefore, the results of the experiment provided no support for our initial hypotheses and are incongruent with the conceptual link between increased sensory feedback and increased sense of presence in VEs [2, 3].

One interpretation of the nonsignificant findings from the current experiment is that body-based haptic feedback may not always increase sense of presence and PX levels in VR gaming. Regarding sense of presence, it is a multifaceted construct and while the involvement of the player in an experience is essential, it is not the sole factor [2]. Witmer and Singer believe that perceptual fidelity along with other sensory factors affect levels of presence for the player [2]. However, while a good sensory experience can enhance presence for a player, it is also likely that an unpleasant experience can decrease reported presence levels. The overall experience provided by the haptic vest could have been overwhelming for some participants, which might, in turn, have led to lower levels of presence. Anecdotally, while some of our participants commented that their gaming experience was enhanced by the vest, others found that the haptic feedback through the vest was distracting their attention away from the main experience. As the VR experience continues to develop and the simulations provided become more

realistic, further research should be done to ensure the best possible gaming experience for players.

Another interpretation why the hypotheses were not supported is related to the unfamiliar nature of receiving body-based haptic feedback through a vest. Experiencing the sensation of touch through a haptic vest is not usual in everyday reality (at least at the time this paper was written). Therefore, while those users who enjoy the tactile experience will likely enjoy the sensations the haptic vest provides, others who primarily use other senses might not. Thus, receiving haptic feedback through a vest might be distracting and detrimental to sense of presence.

A limitation of this study was the use of a single genre of music. Music taste could have an impact on the levels of PX and presence when playing a song-based rhythm game in VR, depending on how the user feels about the music. It would be prudent for future studies to investigate the effect of different music genres. One possibility is to give participants the chance to select the song they would like to play. Further research should also investigate the same hypotheses within the context of playing games from a different genre. It may be the case that the effect of body-based haptic feedback on sense of presence and PX is more pronounced when playing a first-person shooter game.

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