The Impact of Controller Type on Video Game User Experience in Virtual Reality

Daniel Hufnal
Department of Computer Science
State University of New York at Oswego
Oswego, NY, USA
dhufnal@oswego.edu

Ethan Osborne
Department of Computer Science
State University of New York at Oswego
Oswego, NY, USA
eosborn2@oswego.edu

Theodore Johnson
Department of Computer Science
State University of New York at Oswego
Oswego, NY, USA
tjohnso9@oswego.edu

Caglar Yildirim*
Department of Computer Science
State University of New York at Oswego
Oswego, NY USA
caglar.yildirim@oswego.edu

***Abstract*—The recent resurgence of interest in and widespread availability of virtual reality (VR) technology have paved the way for the use of VR systems as a gaming console. With the incessant popularity of VR gaming, the question then arises as to which input method affords the most intuitive interactive experience and provides the most enjoyable gaming user experience (UX). In an attempt to address these questions, the current study examined the impact of controller type (native VR controller vs. traditional gamepad controller) on video game UX in VR while playing a strategy game and an FPS game. Using both the native VR controller and traditional gamepad controller in a counterbalanced order, participants played a strategy and FPS game in VR and provided video game UX satisfaction ratings. Results of the strategy game experiment indicated that the two controllers were comparable in terms of perceived controller naturalness, sense of presence, and video game UX satisfaction during the gameplay, indicating that using a more natural input device did not lead to a superior VR gaming UX. Results of the FPS game experiment indicated that the two controllers were comparable in terms of, sense of presence and video game UX satisfaction during the gameplay, indicating that using a more natural input device did not lead to a superior VR gaming UX. However, results indicated that perceived controller naturalness was rated higher in the Oculus controllers than in the Xbox controllers, exhibiting that the Oculus controllers felt more natural.**

Keywords—VR gaming, controller naturalness, virtual reality gaming, video games, gaming user experience, UX

I. INTRODUCTION

Video games have come a long way since they were first introduced to the world. Along with very significant changes in game design, graphics and gameplay, came changes to the hardware utilized to power these games and drive and to encourage the development of these changes and innovations. To enjoy these games, one needs a form of input for control and to interact with the environment, however. In addition to the advancements in technology and games came many introductions, refinements, and reimaginings of controllers and other types of input devices designed for the purpose of interacting with video games and virtual worlds. From joysticks, controllers and gamepads, steering wheels and pedals, to the humble but still very relevant mouse and keyboard, video game input methods have gone through numerous iterations leading to where they are at present.

With the advent of virtual reality (VR) and its relative ease of access for people, the development of new methods of input and control has begun again. Is such a thing completely necessary however? With all the choices out there and games that are built from the ground up with VR in mind, how does one decide what the best input method for them is? Are VR specific controls the more preferable way to enjoy a VR experience or is it perhaps something more traditional with which more people already have substantial experience.

* Corresponding author

978-1-7281-2404-9/19/$31.00 ©2019 IEEE

A. Video Game UX

Video game user experience is a vital component in the development and creation of video games. The games not only have to be functionally playable, but also something that the players will enjoy. There are many factors that influence the overall user experience in video games. In this study, we attempt to look at the video game user experience in VR and how the method of control input affects it.

There are many factors that affect game user experience; the involvement that a user experiences, the immersive elements of the game that lead to a greater feeling of presence, and the controllers that are being used to interact with the game. Having all the factors met to a satisfactory standard can be indicative of a game with a high user experience; one that is sure to bring in many players as well as bring them enjoyment.

Prior research has indicated that the notion of engagement plays a significant contribution in game satisfaction and enjoyment, which is an indicator of good video games [1]. With higher levels of player engagement, the user will have a better video game user experience.

Presence is a construct that continues to be complicated to define. Many researchers have tried, but the fact remains that it is a highly subjective feeling that is also contextual. Being present in class, for example, is not the same as being present in a virtual environment. Slater and Usoh [2] stated this along with the idea that to be present the person needs to have a suspension of disbelief, wherein the person believes they have been transported to the environment [2].

Along with the need for a suspension of disbelief, Slater and Usoh also conveyed that exogenous factors are important when speaking about presence [2]. One of the exogenous factors that was mentioned as being important in maintaining presence was the ability to interact with objects or complete a task. A factor that decreased presence in the virtual environment was that some things did not behave naturally. The authors believed that this was in correlation to the 3D mouse that was used in their experiment.

In a later experiment, Slater and Usoh, along with Linakis and Kooper determined two more factors that were important in presence [3]. The first variable is the extent to which the environment models the real world that it is trying to replicate. The second variable is the extent to which proprioception and sensory data match. Both of these variables have something in common: everything in the virtual environment has to match that which is has been done in the real world. During the experiment in this paper, it was found that users performed better playing chess in the condition where they were playing in a garden environment. They also performed worse playing chess in a neutral environment, which matches with the authors definition of presence.

Immersion is another factor that is typically characterized alongside presence; both can take away from or enhance one's experience in a virtual environment. Immersion is what causes the user to feel present in the virtual environments. According to Mestre [4], immersion is achieved when real world sensation is replaced with that of the VE. By ensuring that virtual environments, and more importantly the corresponding games, immerse the user and make them feel present in the environment, virtual reality will continue to grow as a video game medium.

In an experiment done by Nacke and Lindley, they defined immersion through a sensory lens [5]. The criteria that they laid out for an immersive experience included having a complex and exploratory environment, having various types of opponents, having fitting sensory effects, and others. With these variables, the authors made the case that the user would be more immersed in their environments and thus would have a greater experience overall.

B. Controllers

The controller used to play a video game is essential to the entire experience. Without a way to manipulate the virtual world in front of the player, there would be no game. The interactivity in the gameplay provided by the controller is what makes video games the unique form of entertainment that they are.

One exploratory study investigated how four different input devices (mouse, keyboard, gamepad, and joystick) performed in a virtual environment [6]. The authors utilized a survey as well as took subjective ratings of the participants to find out what input device performed highest and was the most comfortable. Results of this study indicated that the mouse was preferred due to it performing best, the accuracy of it, and how easy it was to use.

Similarly, Bowman et al. investigated the benefits of playing games where the controllers were natural user interfaces (NUIs) as opposed to a regular gamepad [7]. In this study, participants were asked about how they felt using regular gamepads and how they felt using natural user interfaces, such as the Nintendo Wiimote. Results of this paper showed that most participants preferred the gamepad over the NUIs due to the NUIs feeling unnatural, the lack of precision while using them, and the participant having less success while using them. It was also noted that NUIs were utilized more in sports games, as opposed to gamepads, which were utilized more in first and third person shooter games. This could be a result of correlating a NUI's use in sports games to their real-life sports equivalent.

A study by McGloin and Krcmar [8] investigated perceived controller naturalness in video games using a Nintendo Wiimote controller and a PlayStation 3 controller. Participants were asked to fill out an instrument on their knowledge of tennis and video game skill level. They practiced for 15 minutes and then filled out a second instrument asking about demographics, video games, tennis video games, and skill level. They then had a 15-minute play session and filled out a final instrument asking about perceived controller naturalness, perceived video game realism, perceived spatial presence, and game enjoyment. Results indicated more perceived controller naturalness in the Nintendo Wiimote controller due to the users overall scores of spatial presence, game realism, and enjoyment. The results also indicated that perceived controller

naturalness predicted perceived spatial presence and perceived game realism. Results also showed that perceived realism of graphics and sound also positively influenced perceptions of spatial presence. The results of this study showed that the more natural the controller was perceived to be, the more enjoyable the gaming experience was. Additionally, spatial presence also significantly predicted game enjoyment. The authors believe that natural controllers are indicative of a more realistic experience and a higher enjoyment.

Along with controller naturalness, another important factor to mention is video game interactivity in relation with presence and video game enjoyment. Skalski et al. [9] investigated whether or not different video game controller types might influence a user's level of perceived naturalness, presence, and game enjoyment. In the first experiment, controller type was manipulated. Participants played *Tiger Woods PGA Tour 07* for 10 minutes with either a Wiimote or Playstation 2 (PS2) controller and then filled out a questionnaire. In the second experiment, controller was manipulated again but participants played a driving game. They played for 10 minutes on either a keyboard, joystick, gamepad, or a steering wheel and then filled out a questionnaire and the experimenter noted down what place they finished in for the race to track performance as a function of the controller. Results from experiment 1 showed that the Wiimote was perceived as significantly more natural than the PS2 controller, indicating that an incomplete tangible mapped controller would be perceived as more natural than a controller with simple directional mapping and perceived naturalness of a controller predicted spatial presence. In experiment 2, results indicated support for the prediction that the steering wheel would be perceived as more natural than the other conditions [9]. Additionally, as a result of the path analysis in experiment 2, realistic tangible natural mapping can create a sense of spatial presence that directly impacts enjoyment which is consistent with the authors original expectations.

Gerling, Klauser, and Niesenhaus [10] looked at the effect of game controls on player experience. They looked at the impact of mouse and keyboard compared with a gamepad on both a desktop computer and a PlayStation 3. The study grouped players into either a platform they were comfortable with or not comfortable with. The results indicated that player experience was affected mostly by whether or not they were comfortable with the platform they were assigned to and partially by the controller hardware. The authors attributed this to a possible lack of familiarity with the less comfortable platform and controller. This study shows a possible change in video game experience on two different controllers and two different platforms. If any issues with controller or platform familiarity could be properly addressed, it would be possible to achieve a more accurate result from changing controllers.

Birk and Regan [11] used self-determination theory (SDT) to look at player experience while manipulating the type of controller used. The participants in the study were asked to play a game that was created specifically for the experiment. Participants played the game using an Xbox controller, PlayStation Move controller, and the Microsoft Kinect. The results showed multiple effects of controller choice on the player's game-self and their player experience. There was a significant interaction between controller choice and positive affect. The Microsoft Kinect controller showed higher results for positive affect followed by the Move, then the gamepad. Additionally, the gamepad was less enjoyable than both the Move and the gamepad. The results also indicated a main effect of controller on Competence, Autonomy, Relatedness, Immersion and Intuitive Controls in Player Experience Needs Satisfaction (PENS). The Move showed higher competence, the Kinect provided higher autonomy, the Kinect again provided higher relatedness, immersion was highest for the Kinect, and the Move was the most intuitive, followed by the gamepad and then the Kinect. Lastly, there was a main effect of controller on the in-game personality of the player as well. Overall, the results indicate that the choice of controller affects the in-game personality of the player which predicts positive affect and intrinsic motivation during gameplay confirming that analysis of in-game personality is important for overall player experience [11]. This study does not indicate whether one control type is superior to another, but rather highlights the fact that the controller choice in a game has a significant effect on player experience in a video game and provides some insight into some future directions which could involve taking into account the in-game personality of the players.

C. Current Study

Previous work concerning video game experience and controllers indicate that the type of controller used during the gameplay influences the video game UX in different ways. That said, little has been done to address the same question within the context of VR gaming, which is on the rise [12]. In the current study, two experiments were carried out to investigate the impact of controller type on video game UX during VR gaming. Experiment 1 addressed this objective within the context of playing a strategy game, while Experiment 2 utilized a first-person shooter (FPS) game. Participants played their assigned video game on a VR headset, Oculus Rift, using the Oculus Touch controllers and Xbox controller. The goal of our study was to examine how changing the input method of a game in virtual reality would affect the game experience and enjoyment of the players. Given that the Oculus Touch controllers would be considered a more natural controller for VR experiences, we hypothesized that the Oculus Touch controllers condition would yield a more satisfactory video game UX than the Xbox controller condition. Additionally, it was hypothesized that the sense of presence experienced when using the Oculus Touch controllers would be higher than with the Xbox controller.

II. EXPERIMENT 1

A. Design

The experiment was conducted using a within-subjects design with counterbalancing. The participants experienced both of the conditions in a counterbalanced order so that half of the participants started off with the natural controllers and then proceeded to the traditional controllers, while the other half did the same in reverse order. The independent variable was the type of controller being used: natural (Oculus Touch Controllers) vs. traditional (Xbox Controller). The dependent variable was the game UX satisfaction, as measured by the Game User Experience Satisfaction Scale (GUESS) score.

B. Participants

A total of 30 participants were recruited to participate in the experiment, resulting in a sample of 11 females and 19 males with an average age of 20.8 (*SD* = 2.91). Participants voluntarily signed up for the experiment by visiting an online sign-up page sent via email. Participants were compensated by being entered into a drawing of three $10 Amazon.com gift cards as well as being given extra course credit.

C. Materials

1) Video Game

The video game *Defense Grid 2: Enhanced VR Edition* [13] is a single player tower defense style strategy game developed by Hidden Path Entertainment. The game is viewed by the players in a top-down perspective with the player looking over the playing field from the sky allowing them to see everything and manipulate the field and buildings. The players defend their base from repeated waves of aliens by building towers using resources that are accumulated over time by defeating the various aliens in the waves. There are multiple towers that can be built all using a different attack type that pertain to different weaknesses that the different aliens have. Players also have the option to upgrade towers to improve their abilities. This game was chosen because it is playable in VR with both the Xbox controller as well as the Oculus touch controllers and are very similar using buttons to make selections. The only difference is that players can point with the touch controllers while they had to aim by moving their head around with the Xbox controllers. Additionally, the game has also been used in previous research on VR and gaming with the Oculus Rift [14].

2) VR Headset

The game was played exclusively on an Oculus Rift HMD for the experiment. It has features such as stereoscopic 3D, positional tracking, an accelerometer, and a gyroscope. It also makes use of two OLED displays, one in front of each eye, with a resolution of 1080x1200 for each eye, a 90Hz refresh rate, a 110-degree field of view, and integrated headphones [15, 16] creating an immersive and compelling virtual environment for the players. It allows the players to use their head to move around in the environment and immerse themselves with the game.

3) Game User Experience Satisfaction Scale

The Game User Experience Satisfaction Scale (GUESS) is a psychometrically validated construct created to avoid some of the limitations present in other gaming related measures. It contains nine different subscales that are indicative of video game enjoyment and satisfaction such as Usability/Playability, Narratives, Play Engrossment, Enjoyment, Creative Freedom, Audio Aesthetics, Personal Gratification, Social Connectivity, and Visual Aesthetics [1]. There is a total of 55 items, rated on a 7-point Likert-scale. Given the nature and gameplay of the strategy game used in the current study, we concluded that the dimensions of Narratives and Social Connectivity did not apply here and were excluded from the questionnaire. In line with the scoring guide for the scale [1], an average subscale score for each of the remaining seven dimensions was computed and then summed up to calculate the overall GUESS score for each participant.

D. Procedure

Participants signed up for designated time slots and were directed to the lab to participate in the experiment at their assigned time. After reading and completing an informed consent form, participants sat in front of a desktop computer with an Oculus Rift connected and the experiment began.

Participants were then given a brief overview of the Oculus Rift and how to put it on and adjust the tightness of it as well as how to adjust the interpupillary distance using the slider under the right side of the device. They were then asked about their familiarity of Tower Defense games like *Defense Grid: 2* and given an overview of what the gameplay is like and what the objective of the game is. Afterwards, they were given instructions on how to operate the controller that they were going to use, either the Oculus Touch controllers or the Xbox One controllers and the controls for the game.

Participants played the game on normal difficulty starting on the prologue level and were told to restart upon loss or to continue as long as possible through the levels until 10 minutes had elapsed. They were given instruction on how to play the game, the goal, and what the various UI elements showed. Instruction included a short tutorial from the experimenters and the participants were alerted to a UI element that displayed the button mappings on the controller. During the gameplay, the experimenter exited the room leaving the participant alone to play for 10 minutes.

After 10 minutes elapsed, the experimenter re-entered the room and directed them to the online questionnaire containing the GUESS questionnaire. The participant was told to complete it and to alert the experimenter when they were finished. At this point, the experimenter left the room again and waited until the participant had finished the questionnaire and came to get them.

After the completion of part 1, part 2 began and the participant and experimenter repeated the above steps except using the other controller that was not used in the first part. Participants played the same game for another 10 minutes and the experimenter then directed them to another online questionnaire containing the GUESS as well as any debriefing information for them to read. It was at this point the experiment was concluded and the participants were thanked for their time and participation as well as given any forms required to receive extra course credit.

E. Results

To test the hypotheses presented earlier, we conducted several descriptive and inferential statistics tests. Table 1 presents a summary of these tests for each of the dependent variables of the experiment.

Table 1. Results of Hypothesis Testing

	M (*SD*)	*t(29)*	*p*
Controller Naturalness		.238	.813
Xbox	4.65 (1.35)		
Oculus Touch	4.73 (1.41)		
Sense of Presence		.000	1
Xbox	4.66 (1.15)		
Oculus Touch	4.66 (1.19)		
Game UX		.919	.366
Xbox	39.53 (4.68)		
Oculus Touch	39.92 (5.20)		

Alpha level set at .05 for all hypothesis tests.

A paired-samples *t* test was conducted to compare participants' perceived controller naturalness, sense of presence levels, and video game UX ratings for the Xbox and Oculus Touch controllers. The assumption of normality, as assessed by Shapiro-Wilk's test, ($p > .05$) was met in all of the tests. Results showed that there was no statistically significant difference between the Xbox ($M = 4.65$, $SD = 1.35$) and Oculus Touch ($M = 4.73$, $SD = 1.41$) controllers in perceived controller naturalness, $t(29) = .238$, $p = .813$.

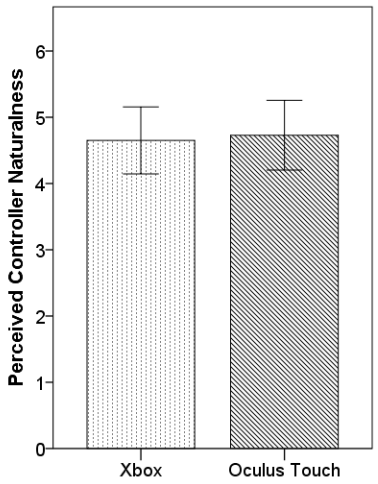

Fig 1. Perceived Controller Naturalness Levels in Experiment 1

Regarding the effect of controllers on sense of presence, results revealed no significant differences between the Xbox ($M = 4.66$, $SD = 1.15$) and Oculus Touch ($M = 4.66$, $SD = 1.19$) controllers in sense of presence levels, $t(29) = .000$, $p = 1$.

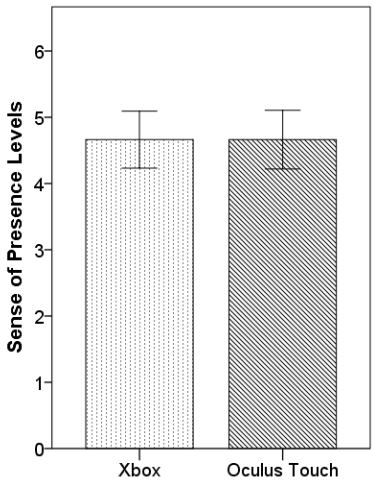

Fig 2. Sense of Presence Levels in Experiment 1

As for the effect of controllers on video game UX ratings, results showed that the Xbox ($M = 39.53$, $SD = 4.68$) and Oculus Touch ($M = 39.92$, $SD = 5.2$) controllers did not differ in the video game UX ratings either, $t(29) = .919$, $p = .366$.

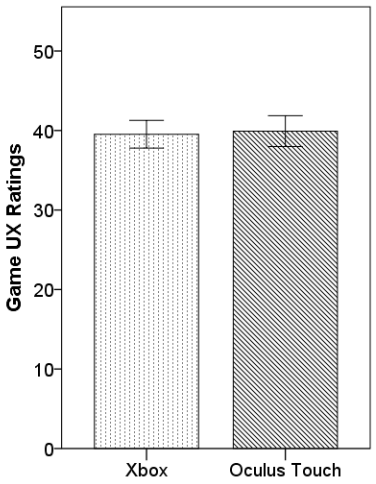

Fig 3. Game UX Ratings in Experiment 1

F. Discussion

Experiment 1 investigated the effects of controller type on game UX in VR while paying a top-down style tower defense video game. Results from this experiment indicated that using the Oculus Touch controllers in VR did not result in higher levels of game UX while playing the strategy game and that there were no significant differences in presence levels between the Oculus Touch controllers versus an Xbox controller in VR, leaving both hypotheses unsupported.

III. Experiment 2

Experiment 1 tested the hypotheses guiding the current study within the context of a strategy game and yielded no support in favor of native Oculus Touch controllers. It is possible that the genre of the game might be an important factor in the impact of controller naturalness on game UX. Perhaps Oculus Touch and Xbox controllers lead to different gaming experiences during another game of a different genre. Experiment 2 was designed to further examine this possibility within the context of playing an FPS game.

A. Design

Similar to Experiment 1, Experiment 2 was conducted using a within-subjects design with counterbalancing. The participants experienced both of the conditions in a counterbalanced order where half of the participants started off with the Oculus Touch controllers and then proceeded to the Xbox controller, while the other half did the same in reverse order starting with the Xbox controller and moving on to the Oculus Touch controllers. The independent variable was the type of controller being used: natural (Oculus Touch Controllers) vs. traditional (Xbox Controller). The dependent variable was the game UX satisfaction, as measured by the Game User Experience Satisfaction Scale (GUESS) score.

B. Participants

The sample for Experiment 2 consisted of 34 participants, 18 females and 16 males. The average age of the participants was 20.2 (SD = 1.75). Participants voluntarily signed up for the experiment by visiting an online sign-up page sent via email and received course credit as compensation for their participation.

C. Materials

Experiment 2 utilized the same materials as Experiment 1, with the exception of the video game participants played:

1) Video Game

The video game *War Robots VR: The Skirmish*[15] is a single player First Person Shooter (FPS) that puts the player in the pilot seat of a mech or robot letting them view the world around them from inside of a cockpit. The game is very short with players following a linear path fighting waves of enemies until the game ends in a scripted death scene. The players have the ability to walk around and shoot both missiles and a machine gun. The game was chosen because it supports both the Oculus Touch controllers and the Xbox controller natively. In both scenarios, the gameplay is identical including the controls.

D. Procedure

The procedure for Experiment 2 was identical to that which was followed in Experiment 1. This time, instead of the strategy game, participants were provided an overview of the FPS gameplay. Participants were asked to play the game from beginning to end because it was a short teaser game, taking, on average, 6 - 8 minutes to complete. All other steps were identical.

E. Results

Table 2 presents a summary of hypothesis testing for each of the dependent variables of Experiment 2, along with the descriptive statistics.

Table 2. Results of Hypothesis Testing

	M (*SD*)	*t(33)*	*p*
Controller Naturalness		2.42	.021
Xbox	4.86 (1.38)		
Oculus Touch	5.35 (1.23)		
Sense of Presence		.983	.333
Xbox	5.01 (1.37)		
Oculus Touch	5.15 (1.33)		
Game UX		1.82	.079
Xbox	38.16 (7.02)		
Oculus Touch	38.99 (6.35)		

Alpha level set at .05 for all hypothesis tests.

A paired-samples *t* test was conducted to compare participants' perceived controller naturalness, sense of presence levels, and video game UX ratings for the Xbox and Oculus Touch controllers. The assumption of normality, as assessed by Shapiro-Wilk's test, ($p > .05$) was met in all of the tests. Results showed that there was a statistically significant difference between the Xbox ($M = 4.86$, $SD = 1.38$) and Oculus Touch ($M = 5.35$, $SD = 1.23$) controllers in perceived controller naturalness, $t(33) = 2.42$, $p = .021$. This indicates that Oculus Touch controllers were found to be more natural, compared to the Xbox controller.

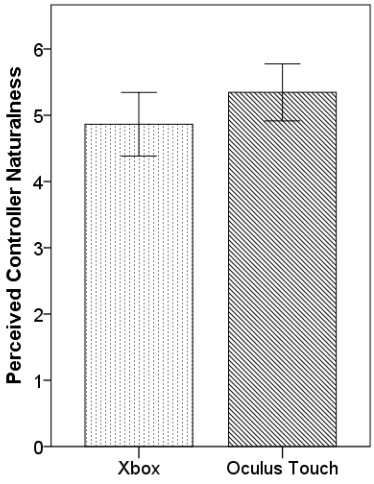

Fig 4. Perceived Controller Naturalness Levels in Experiment 2

Regarding the effect of controllers on sense of presence, results revealed no significant differences between the Xbox ($M = 5.01$, $SD = 1.37$) and Oculus Touch ($M = 5.15$, $SD = 1.33$) controllers in sense of presence levels, $t(33) = .983$, $p = .333$.

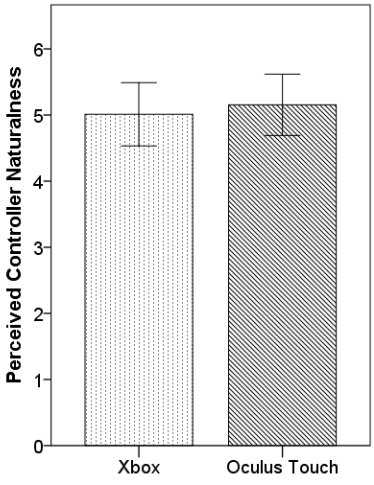

Fig 5. Sense of Presence Levels in Experiment 2

As for the effect of controllers on video game UX ratings, results showed that the Xbox ($M = 38.16$, $SD = 7.02$) and Oculus Touch ($M = 38.99$, $SD = 6.35$) controllers did not differ in video game UX ratings, $t(33) = 1.82$, $p = .079$.

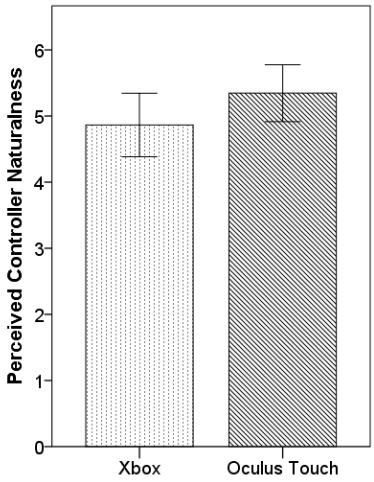

Fig 6. Game UX Ratings in Experiment 1

F. Discussion

Experiment 2 investigated the effects of controller type on game UX in VR while playing a first-person shooter (FPS) video game. Results revealed that the Oculus Touch controllers did not lead to a greater sense of presence and a greater game UX during VR gaming than did the Xbox controllers, thus leaving both hypotheses unsupported. However, in line with previous studies [5-6], the results provided evidence in support of the Oculus Touch controllers being perceived as more natural than the Xbox controllers.

IV. General Discussion

The purpose of this study was to investigate the impact of controller type on game UX in VR while playing a strategy game and an FPS game. There were two hypotheses: using the Oculus Touch controllers would result in a higher game UX than an Xbox controller, and playing using the Oculus Touch controllers would result in a greater sense of presence than playing using the Xbox controller. Overall, results of this study indicated that there was no significant difference in game UX or sense of presence between the Xbox controller and Oculus Touch controllers in both game genres. However, while Experiment 1 showed no difference in perceived controller naturalness, Experiment 2 showed that the Oculus Touch controllers were perceived to be more natural than the Xbox controller. This could possibly be attributed to the effect of game genre on perceived controller naturalness. In the FPS game, the missiles and guns were fired from the left and right trigger on the controllers respectively, which could have resulted in a more naturally mapping to the Oculus Touch controllers, compared to the mapping of the controls in the strategy game.

In previous work, it has been shown that perceived controller naturalness, presence, and game enjoyment are all related [8, 9, 19]. Skalski et al. [9] described a typology of natural mapping and discussed possible types of natural

mapping. Two out of the four mappings that pertained to the current study were incomplete tangible natural mapping and directional natural mapping. The Oculus Touch controllers fall under the category of incomplete tangible natural mapping and the Xbox controller is directionally mapped [9]. Skalski et al, [9] point out that directional mapping is a basic form of natural mapping that most people are familiar with on most gamepads such as the Xbox controller where pushing "up" or "left" on the joystick makes the character in the game move up or left on the screen or forward and backward in the environment. They also state that it is the least natural of the four types of natural mapping that they discuss. Incomplete tangible natural mapping is the second most natural mapping that involves giving the player something that partially simulates the feel of an object or action in the environment. The players grasp the controller like they would an object in real life. An example of this is playing a shooting game using and holding the controller like a gun and using it to aim and shoot. It is incomplete because it does not have the real shape or weight of the actual object [9]. Based on this discussion, the Oculus Touch controllers are the more naturally mapped control method when compared to the Xbox controller. These findings appear to be supported by Experiment 2 where the controls may have felt more naturally mapped with the Oculus Touch controllers. This could also explain why perceived naturalness was not supported in the first experiment. There was no natural mapping between the controls of DG2: Defense Grid 2 and the Oculus Touch controllers.

The Oculus Touch controllers in Experiment 2 may have been perceived as more natural due to some level of natural mapping with the controls and the fact that the players were placed inside of a cockpit. The controllers may have felt more like controls in a cockpit such as joysticks and buttons as compared to just holding an Xbox controller while in VR. Further experimentation could be explored with more complete natural mapping such as using a steering wheel and pedals in a driving simulator in VR.

Defense Grid 2: Enhanced VR Edition was thought to be a suitable choice for this study due to the existence of previous research examining the difference in game UX scores with users playing *Defense Grid: 2* using an Oculus Rift [14]. *War Robots VR: The Skirmish* was chosen because it was an FPS, free and supported both controller methods. Other game genres that have been used in controller naturalness studies are sports games [8, 9] driving games [9] and original games [11]. These studies all found that there were higher levels of game enjoyment when levels of perceived controller naturalness were higher. Seibert and Shafer [19] also investigated the link between VR and perceived controller naturalness. Results indicated that how natural the controller felt regardless of how it was mapped was an important determinant for spatial presence explaining for more than 40% of the variance in their results. Seibert and Shafer concluded that using a VR headset resulted in greater perceived controller naturalness, which increased the participants' presence levels in the game environment.

This leads us to surmise that our lack of significant results may be attributed to this phenomenon. The Oculus Rift headset was encouraging our participants to perceive both controllers as equally natural regardless of their mapping leading to similar scores across all the dimensions. Overall, our results seem to indicate that there may not be a difference in controller choice when playing VR strategy games when it comes to presence, perceived naturalness, and gaming UX. However, Experiment 2 showed that in games with controls that are more naturally mapped to take better advantage of the controller that they are utilizing, there appears to be a significant difference in perceived controller naturalness. Unfortunately, the perceived controller naturalness alone was not enough to obtain significant results in the other dimensions. It is difficult at this time to conclude that there is no difference in VR FPS games in general because there are some out there that utilize more naturally mapped controls. One implication from the current study is that for consumers, unless the game explicitly requires it, it may not be always necessary to purchase the Oculus Touch controllers with the hopes of feeling a better gaming UX.

A limitation of the current study was that we were limited in time and resources to make use of multiple genres of games at the same time. As previously mentioned, most research has suggested that natural controllers are indicative of a better game UX. This is due to the natural motions of the sports being able to be utilized with the natural controllers [7, 8]. Future work should examine the effect of controllers and different game genres on game UX. Another possibility is to compare VR gaming to traditional desktop gaming while also manipulating controller type and including other game types. From these results, we can then run multiple analyses comparing different variables to elucidate which combination of controller type produces the highest levels of player immersion and perceived controller naturalness. These results can be used to aid VR game designers and developers when determining what controllers should be used for the type of game being developed.

ACKNOWLEDGMENTS

The study was conducted in the SUNY Oswego VR First Lab, established through the academic partnership between VR First and SUNY Oswego. The authors would like to thank VR First for supporting the establishment and maintenance of the lab.

REFERENCES

[1] M. H. Phan, J. R. Keebler, and B. S. Chaparro, B. S. (2016). The development and validation of the Game User Experience Satisfaction Scale (GUESS). Human Factors, 58(8), 1217-1247.

[2] Slater, M., & Usoh, M. (1992). Presence in Immersive Virtual Environments, 5-7.

[3] Slater, M., Linakis, V., Usoh, M., & Kooper, R. (1996, July). Immersion, presence and performance in virtual environments: An experiment with tri-dimensional chess. In *Proceedings of the ACM Symposium on*

Virtual Reality Software and Technology (pp. 163-172). ACM.

[4] Mestre, Daniel. (2006). Immersion and Presence.

[5] Nacke, L., & Lindley, C. A. (2008, November). Flow and immersion in first-person shooters: measuring the player's gameplay experience. In *Proceedings of the 2008 Conference on Future Play: Research, Play, Share* (pp. 81-88). ACM.

[6] Lapointe, J. F., Savard, P., & Vinson, N. G. (2011). A comparative study of four input devices for desktop virtual walkthroughs. *Computers in Human Behavior*, *27*(6), 2186-2191.

[7] Bowman, N., Pietschmann, D., & Liebold, B. (2017). The golden (hands)rule: Exploring user experiences with gamepad and natural user interfaces in popular video games. *Journal Of Gaming & Virtual Worlds*, *9*(1), 71-85.doi: 10.1386/jgvw.9.1.71_1.

[8] Rory McGloin and Marina Krcmar. 2011. The impact of controller naturalness on spatial presence, gamer enjoyment, and perceived realism in a tennis simulation video game. Presence: Teleoper. Virtual Environ. 20, 4 (August 2011), 309-324.

[9] Skalski, P., Tamborini, R., Shelton, A., Buncher, M., & Lindmark, P. (2011). Mapping the road to fun: Natural video game controllers, presence, and game enjoyment. *New Media & Society*, *13*(2), 224-242.

[10] Gerling, K. M., Klauser, M., & Niesenhaus, J. (2011, September). Measuring the impact of game controllers on player experience in FPS games. In *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments* (pp. 83-86). ACM.

[11] Birk, M., & Mandryk, R. L. (2013, April). Control your game-self: effects of controller type on enjoyment, motivation, and personality in game. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 685-694). ACM.

[12] Yildirim, C., Carrol, M., Hufnal, D., Johnson, T., & Pericles, S. (2018). Video Game User Experience: To VR, or Not to VR? *2018 IEEE Games, Entertainment, Media Conference (GEM)*. doi:10.1109/GEM.2018.8516542

[13] Hidden Path Entertainment and 505 Games (2014, Sept). DG2: Defense Grid 2. Steam [Online]. Available: https://store.steampowered.com/app/221540/DG2_Defense_Grid_2/

[14] Shelstad, W. J., Smith, D. C., & Chaparro, B. S. (2017). Gaming on the Rift: How Virtual Reality Affects Game User Satisfaction. Proceedings of the Human Factors and Ergonomics Society Annual Meeting,61(1), 2072-2076. doi:10.1177/1541931213602001

[15] Buy Oculus Rift + Touch - Microsoft Store. (2018). [Online]. Available: https://www.microsoft.com/en-us/p/oculus-rift-touch/8mt5ws8lgbwl?activetab=pivot:techspecstab

[16] Oculus Rift Specs. (2018). [Online]. Available: https://www.cnet.com/products/oculus-rift/specs/

[17] Pixonic (2017, Aug). War Robots VR: The Skirmish [Online].Available:https://store.steampowered.com/app/672640/War_Robots_VR_The_Skirmish/

[18] Tamborini, Ron & , Ron & Eastin, Matthew & S, Matthew & , Skalski & , Paul & Lachlan, Kenneth & , Kenneth & , Fediuk & A, Thomas & , Brady & , Robert. (2004). Violent Virtual Video Games and Hostile Thoughts. Journal of Broadcasting & Electronic Media. 48. 335-357.

[19] Seibert, J., & Shafer, D. M. (2018). Control mapping in virtual reality: effects on spatial presence and controller naturalness. *Virtual Reality*, *22*(1), 79-88.