ABSTRACT

An Exploratory Study on Virtual Reality Head Mounted Displays
and Their Impact on Player Presence

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This study explores how a video game player's sense of being in a game world (i.e., spatial presence) is impacted by the use of a virtual reality head-mounted display. Research focused on virtual reality research has fallen by the wayside since the early 90s due to the limitations in the technology. With modern reimagining of virtual reality head-mounted displays, there is now an opportunity to reexamine the impact it has on gaming experience. This thesis explores the results of an experiment in which university students played video games using either the Oculus Rift VR head set or a standard monitor while playing a first-person shooter (FPS) video game. Control interface was also manipulated. Results indicated that virtual reality head mounted displays have a positive impact on a players' level of spatial presence, but they can also produce negative feelings that counteract that sense of presence in its impact on enjoyment.

An Exploratory Study on Virtual Reality Head Mounted Displays
and Their Impact on Player Presence

by

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CHAPTER ONE

Introduction

Virtual reality (VR) technology showed great promise and was of great interest to a wide array of disciplines during the late 1980s and early 90s. Though it seemed as though VR technology would diffuse into homes, it never materialized (Bracken & Skalski, 2010). However, out of this initial interest in VR technology came a strong interest in features of video games that create the sense of being in a virtual space, and its varying dimensions (Bracken & Skalski, 2010). This interest has led to a great deal of work on the concept of presence (e.g., Bracken & Skalski, 2010; Skalski & Whitbred, 2010; Vorderer 2004; Hou 2012) as it relates to video games and an emerging interest in control mapping (Skalski & Whitbred, 2010; Klimmt, Hartmann & Frey 2007; Limperos, Schmierbach, Kegerise, & Dardis, 2011). Despite increased scholarship on the concept of presence and related factors such as control type or mapping (Shafer, Carbonara & Popova, 2011; Skalski et al., 2011) there is very little current research concerning presence and mapping as it directly relates to VR technology. However, technology has advanced to the point where creating a more advanced VR headset is possible. A new generation of VR technology, most notably the Oculus Rift, is close to being released to the public and interest in VR is being revitalized. Therefore, the main focus of this study is to examine this new generation of VR technology and to discover whether or not it has a positive impact on players' levels of presence. In addition, the study explores controller naturalness when motion based control types are paired with VR technology.

CHAPTER TWO

Literature Review

Virtual Reality Technology

VR technology is a tool by which humans can directly interact with computers in order to solve far more complex problems than by using strictly traditional interface methods (Burdea & Coiffet 2003). "Virtual reality is a high-end user-computer interface that involves real time simulation and interactions through multiple sensorial channels. These sensorial modalities are visual, auditory, tactile, smell and taste" (Burdea & Coiffet, 2003, p. 3).

Another element Burdea and Coiffet mention is software capable of emulating realistic environments. This is the area in which video games progressed the most. Developers now have the ability to create stunningly realistic worlds populated with artificial intelligences who behave in believable manners (Tamborini & Bowman, 2010).

The specific pieces of technology discussed by Burdea and Coiffet (2003) do vary somewhat in the current implementation of VR. This difference is primarily found in the input devices. Burdea and Coiffet discuss the use of motion tracking gloves and body suits to interact with virtual environments. The modern iteration of VR technology is relying on more traditional control types such as mouse and keyboard controls and game pads.

There is far more to virtual reality than simply the various pieces of technology that people most directly associate with virtual reality. Steuer (1992) argues that VR is more than just a technological definition, it is experiential. He argues that VR is more than just the use of a head-mounted display (HMD), or motion tracking gloves; it is the experience of feeling as though you are in a different place, a virtual reality. "A 'virtual reality' is defined as a real or simulated environment in which the perceiver experiences telepresence" (Steuer, 1992, p. 7). This conceptual understanding of VR allows for a far broader interpretation of what constitutes a virtual reality.

Steuer (1992) goes on to develop two primary descriptors for a virtual reality: vividness and interactivity. Vividness is described as how fully a technology represents the environment it is simulating to a user across multiple sensory channels (Steuer, 1992). Interactivity is defined as the extent a user is capable of modifying the form and content of the virtual environment they are in (Steuer, 1992).

The idea of vividness is further broken down into the ideas of the breadth and depth of vividness. Simply put, the breadth is the ability of a medium to stimulate a user's various senses simultaneously. For example, a book is less vivid than a film, due to the fact a film stimulates vision and hearing simultaneously. The depth of vividness is essentially just the quality of an image or experience (Steuer, 1992).

Steuer (1992) breaks down interactivity into three factors: speed, range and mapping. Speed is the rate that input is assimilated into the environment. Range is the breadth of possible actions a user can take. Mapping is ability for a system to have a set of controls where taking the range of actions makes sense to the user (Steuer, 1992). So by those definitions, video games would clearly be classed as a highly interactive media though clearly with variations across genres and individual games.

With Steuer's conceptualization of virtual reality, it becomes reasonable to state that VR is not just a technology, but also something users experience and interact with.

With that in mind, the use of a HMD and other motion based controls are just different ways by which players are able to experience presence within these virtual realities.

Defining Presence

According to Steuer, "Telepresence is defined as the experience of presence in an environment by means of a communication medium" (Steuer, 1992, p. 6). However, there does seem to be some debate as to the exact terminology that should be used when referring to this concept. Bracken and Skalski (2010) discuss the issue of whether to call this concept 'telepresence' or 'presence'. According to Bracken, several seminal works such as Lombard and Ditton (1997) and Sheridan (1992) call this concept 'presence', resulting in 'presence' becoming the dominant term in communication literature. However, Lombard (2008) expressed some concern over the use of 'presence' in that the term is used by other groups which do not study 'presence' as a media concept. It is suggested that adding 'tele' implies mediated presence which is more in line with media studies. However for the purposes of this work, this central concept will be referred to as 'presence'.

As stated earlier, immersion has been of great interest to the games industry. It has also drawn the attention of researchers under the name of presence. Because there is a large amount of presence research across various fields and focuses, the exact definition of the concept is still unclear. Tamborini and Skalski (2006) and Tamborini and Bowman (2010) describe presence as a multidimensional psychological state in which a user’s experience in a virtual space is shaped by the technological features of that space that are not immediately apparent to the user. Westerman and Skalski (2010) describe presence as a sense of 'being there' which is caused by media technology, or a perceptual illusion of non-mediation. Hartmann, Klimmt and Vorderer (2010) call presence an umbrella term used to describe a variety of experiences. The commonality of these experiences is that the user is either less aware or completely unaware of the mediated nature of the experience. Lombard and Ditton (1997) once again describe a multifaceted concept, but it all ties in to the idea that presence is the perceptual illusion of non-mediation. The common thread through the literature seems to be that while presence is a complex and multidimensional concept, it can be described as a sense of 'being there'. A slightly more in depth definition would be that a sense of presence is the illusion of non-mediation, which means the user of some technology believes they are actually in a virtual space, and they fail to account for the fact that they are actually interacting with a piece of technology. Presence is also not strictly limited to highly interactive forms of media like video games. Presence research definitely exists outside the realm of video games covering areas such as television and film (Vorderer, Klimmt, & Ritterfeld, 2004).

This idea extends into almost any media. The important thing concerning presence is that no matter the media, if the person interacting with the media feels like they are actually in whatever place they are observing, that is presence (Hartmann et al., 2010; Gibson, 1986).

As was mentioned earlier, researchers have identified several distinct dimensions of presence. There is some variation in the actual terminology but the dimensions are typically listed as spatial presence, social presence and self-presence (Tamborini & Skalski, 2006). Spatial presence, which this study is primarily concerned with, is understood as the sense of actually being physically located in a virtual environment (Tamborini & Bowman, 2010). Social presence is the idea that the user perceives the people in a mediated experience as actual human beings. This is more prominent in massively multiplayer online games (MMOGs) where most virtual characters one encounters are controlled by other players (Tamborini & Skalski, 2006). Self presence is the idea that the player is actually their avatar in the virtual world they are in (Tamborini & Skalski, 2006).

For the purposes of this study, the idea of spatial presence is the one most closely being explored. Thankfully, in regards to video games research spatial presence has received a great deal of attention (Tamborini & Bowman, 2010).

Most research to date has focused on image size, image quality and sound quality in regards to what leads to the greatest increases in presence (e.g., Skalski & Whitbred, 2010; Hou, Nam, Peng & Lee, 2012). There has also been limited research done specifically on VR technology (Tamborini, Eastin, Skalski & Lachlan, 2004).

However the findings of this study did not show that the inclusion of VR improved a user's feelings of presence. In fact, participants who used VR showed lower levels of presence than those using traditional displays (Tamborini et al., 2004).

The affect of image quality on presence has produced mixed results. Bracken and Skalski's (2006) study examined the relationship between image quality and levels of player presence. The study manipulated the image quality between two groups of players who played the same video game. One group of players played the video game in a standard definition and the other played the game in a high definition. Upon comparing the levels of presence between groups, Bracken and Skalski found that manipulating the quality of the image had no significant impact on the players' levels of presence.

The same holds true in Skalski and Whitbred (2010). Their study examined both image quality (standard definition vs. high definition) and standard definition vs. surround sound audio and their influence on player presence. They conducted two different experiments for this study, one for image quality and one for sound quality. Both experiments compared differences between the standard definition condition and the high definition condition. Their findings showed that manipulating image quality did not have a significant impact on levels of player presence. However, they did find that manipulating sound quality did have a significant positive influence on player presence.

Hou et al. (2012), on the other hand, studied the effects that distance from the screen and the screen's size had on presence. In this study, the researchers compared two groups of subjects playing the same video game, with screen size and distance from the screen being manipulated. Condition one used an 81 inch screen viewed from 51.5 inches and condition two used a 12.7 inch screen viewed from 36.5 inches. The findings of this study showed that players using the larger screen experienced higher levels of presence.

It is clear from the existing literature that the type of display used does have an impact on the levels of presence a player experiences. Bracken and Skalski (2006) and Skalski and Whitbred (2010) manipulated the quality of the image (standard definition vs. high definition), not the actual type of the display they used. The findings of Hou et al. (2012), however, show that there is a link between the type of display used and a player's experience of presence. It is with this in mind it is predicted that:

H1: Using a virtual reality HMD will lead to higher levels of spatial presence than using a traditional display device such as a television or computer screen.

Control Methods and Natural Mapping

Norman (1986 & 1988) produced the seminal works concerning the ideas of natural mapping. His work centers on how humans use control interfaces to achieve tasks. Basically, it is the idea of using close analogues of what the user is attempting to accomplish when they interact with a control interface. Research into the topic of game controls have found that control method has a large impact on players' enjoyment of games (Klimmt et al., 2007; Limperos, 2011).

Skalski, Tamborini, Shelton, Buncher and Lindmark (2011) also approach the topic of natural mapping in regards to video games. In this article, the authors lay out a typology of natural mapping. This includes directional natural mapping, kinesic natural mapping, incomplete tangible natural mapping and realistic tangible natural mapping. Directional mapping is the most prevalent form of mapping seen today. The player presses the left direction on the game pad, and their character moves left. Kinesic mapping is found in the Microsoft Kinect and has users performing the actions of their characters but without a tangible controller. Incomplete tangible mapping works by giving players a controller that partially emulates the feel of what they're doing in a game; for example, the Wii remote in a golfing game. Realistic tangible mapping makes use of a tangible, realistic analogue to what the player is using in whatever virtual reality they are engaged in. An arcade game where players use a gun controller to aim and fire at onscreen enemies is an example of realistic tangible mapping (Skalski et al., 2011). The use of this type of natural mapping has thus far been relegated to arcade games or, very rarely, a few home console games. However, due to the surge in interest in VR due to the new technology now in development, such as the Oculus Rift, and advances in motion tracking technology, it is possible to create controllers which fall into the category of realistic tangible natural mapping.

The study conducted in Skalski et al. (2011) explored the influence these different types of controls had on both player presence and player enjoyment. The study consisted of two experiments, both focused on varying control types and examined differences in levels of presence and enjoyment. In experiment one, participants played a golf game using either a Nintendo Wii controller, which is a motion controller, or a PlayStation 2 controller, which is a standard game controller. In experiment two, participants played a driving game using either a steering wheel controller, a keyboard, a gamepad or a joystick. Both experiments showed that using the more natural control type, the Wii controller in study one and the steering wheel in study two, yielded higher levels of presence than the other control types. Initial results showed no significant relationship between presence and enjoyment. Path analysis results on the other hand showed that enjoyment was predicted by presence.

Shafer, Carbonara and Popova (2011) also looked in to the topic of control types and their influence on presence. The authors investigate control types in terms of interactivity. They list the PlayStation Move and Microsoft Kinect as high interactivity, the Wii remote as medium interactivity and standard gamepad controls as low interactivity. Their study consisted of two experiments: the first investigated these three control types across a driving game and a golf game; the second compared the control types across a boxing game. Both studies compared levels of presence and enjoyment between the different conditions. Their findings were that higher controller interactivity lead to higher levels of spatial presence. They also found that higher levels of spatial presence predict higher levels of enjoyment.

The literature concerning controller types as they relate to spatial presence and enjoyment is fairly clear. Control types which are more naturally mapped (Skalski et al., 2011) or more interactive (Shafer et al., 2011) lead to players experiencing higher levels of spatial presence as well as enjoyment. It is therefore predicted that:

H2: A motion-control device will be judged as more natural than a traditional mouse and keyboard.

H3: A control method which is judged as more natural will cause higher levels of presence when paired with a virtual reality HMD than with a standard display type.

In addition to the findings of Shafer et al. (2011) there is further support for the link between spatial presence and enjoyment. Sylaiou, Mania, Karoulis, and White (2010) in a study on virtual museum experiences found that as participants' levels of presence increased their enjoyment of the experience also increased. In other studies however this relationship is not as clear. Both Skalski et al. (2011) and Lin, Duh, Parker, Abi-Rached, and Furness (2002) found that while there was not a direct correlation between increases in presence and increases in enjoyment, they did appear to be related in some way. Both studies were unable to find direct correlations between presence and enjoyment. With path analyses however, both did find that presence did have an influence over enjoyment. With these previous findings in mind, and considering the virtual reality HMD being used is a more advanced model than those previously available it is predicted that:

H4: Increased levels of presence will lead to increased levels of enjoyment.

What remains unknown, however, is what influence the HMD will have on a player's feeling of controller naturalness. Using a virtual reality HMD is a new experience for players and will require an adjustment on their part in how they control the game. With that in mind, the following research question is posed:

RQ1: Will the virtual reality HMD have any influence on perceived controller naturalness?

Also of note is the anecdotal evidence of motion sickness and negative feelings induced by the use of a virtual reality HMD. Merhi, Faugloire Flanagan, & Stoffregen, (2007) investigate this notion of virtual reality HMDs causing motion sickness in users. All conditions used an HMD; the posture of participants (sitting or standing) was the manipulation. The results showed that motion sickness was present across all conditions, with the standing condition having a higher instance of motion sickness. With these results in mind, this study will also measure negative effects of HMD as a covariate.

CHAPTER THREE

Methods

Participants

Participants were 207 undergraduate students from various courses at a research university in the southern-central United States. Participants were offered extra credit for their participation. The sample was about equal between males (*n*= 107) 51.7% and females (*n*= 100) 48.3%. The average age was 20.29 years. Participants were randomly assigned to play a FPS video game using a standard monitor or a VR HMD – the Oculus Rift. The device has a high field of view screen and is capable of very low latency head tracking.

Although not everyone was assigned to use the Oculus Rift, they all had an opportunity to play with it after their session was complete.

Stimulus and Systems

Participants all played the game *Half Life 2* and were randomly assigned to one of four conditions: Condition one (*n*= 55): TV display with mouse and keyboard control set up; Condition two (*n*= 49): Oculus Rift with mouse and keyboard control stet up; Condition three: TV display with Razer Hydra controls (*n*=55); Condition four (*n*= 48): Oculus Rift with Razer Hydra controls. All four conditions played the same segment of *Half Life 2*. *Half Life 2* is a first person shooter in a modern setting and the players were equipped with a pistol and a crowbar. The segment of game play involved in this study required the player to travel through the sewer system of a city. To successfully traverse this environment, players needed to be able to climb ladders, break obstacles, solve basic puzzles and fight enemies which were armed with guns.

Procedure

After giving informed consent, participants were asked to watch a 5 minute video tutorial explaining the controls of the game and where to proceed in the game. Upon completion of the video, participants were given a brief demonstration of the games controls. Then they played the game for 20 minutes. In a between subjects design, participants were randomly assigned to one of six conditions. Immediately after exposure, participants were directed to the online questionnaire containing the items for the dependent and independent variables as well as demographic questions. Total experiment time was approximately 45 minutes. After completing the questionnaire, participants were offered a chance to play with the Oculus Rift and Razer Hydra for up to 15 minutes. Each full session including the experimental tasks and free play time lasted a maximum of sixty minutes.

Measures

Spatial presence was measured by the spatial presence subscale of ITC-Sense of Presence Inventory (ITC-SOPI: Lessiter, Freeman, Keogh & Davidoff, 2001). This measure was composed of 19 items such as "I felt I could interact with the displayed environment." Each item was measured on a five-point scale from "strongly disagree" to "strongly agree." The scale had an observed Cronbach's α=.93.

Negative feelings were measured by the Negative Effects subscale of ITC-Sense of Presence Inventory (ITC-SOPI: Lessiter et al., 2001). This measure was composed of six items such as "I felt disoriented." Each item was measured on a five-point scale from "strongly disagree" to "strongly agree." This measure included six items and had an observed Cronbach's α= .92.

Enjoyment was measured using eight items taken from (Klimmt et al., 2007). Some sample items are: "I liked to play the game" and "I found the game entertaining." Each item was measured on a five-point scale from "strongly disagree" to "strongly agree." This measure had an observed Cronbach's α= .86

Perceived controller naturalness was measured using five items taken from (Skalski et al., 2011). Some sample items are: "The game controls seemed natural" and "The game environment was manipulated in a lifelike manner." Each item was measured on a seven-point scale from "strongly disagree" to "strongly agree." This measure had an observed Cronbach's α= .82.

CHAPTER FOUR

Results

H1 predicted that playing a game with a virtual reality HMD would produce higher levels of spatial presence than playing a game with a standard display. A one-way analysis of variance (ANOVA) was performed; and the results indicated support for H1. Players in the virtual reality condition reported significantly higher levels of spatial presence (*M* = 3.67, *SD* = .60) than players in the standard display condition (*M* = 2.85, *SD* = .68), $F_{(3, 203)} = 14.14$, $p < .001$.

H2 predicted that motion controls would be judged as more natural than mouse and keyboard controls. A one-way ANOVA was preformed and the results did not support H2.There was a significant difference found in controller naturalness between the virtual reality HMD with keyboard and mouse condition (*M*=4.40, *SD*=1.23) and the virtual reality HMD with the Razer Hydra condition (*M*=3.52, *SD*=1.36), $F_{(3, 203)} =3.90$, p=.008. These results run counter to the expectation of the Razer Hydra being a more natural control type than the keyboard and mouse controls. According to these results users rated the mouse and keyboard controls as more natural than the Razer Hydra controls.

H3 predicted that using a control type that is more natural will lead to higher levels of spatial presence when used with a virtual reality HMD than with a standard display. This hypothesis was made with the expectation of comparing the Razer Hydra with standard monitor condition to the Razer Hydra with virtual reality HMD condition. However, due to the findings of H2 this hypothesis compares the keyboard and mouse with standard monitor and the keyboard and mouse with virtual reality HMD conditions. An ANOVA was performed; and the results indicated support for H2. Players in the mouse and key board with virtual reality HMD condition reported significantly higher levels of spatial presence (M = 3.67, SD = .60) than players in the mouse and keyboard with standard display condition (M = 2.85, SD = .68), $F_{(3, 203)} = 14.14$, $p < .001$.

H4 predicted that higher levels of spatial presence would lead to higher levels of enjoyment. Initial ANOVA tests did not support this hypothesis, with no significant differences in enjoyment across the conditions. However, results of a follow up regression analysis indicated that spatial presence and negative feelings had an equally strong yet opposite impact on enjoyment. The overall model was significant, with over 54% of the variance in enjoyment explained, $F_{(4, 195)} = 60.08$, $p < .001$, $R^2_{adj} = .543$. Negative effects had a significant negative impact on enjoyment, $\beta = -.482$, $t = -8.83$, $p < .001$. On the other hand, spatial presence had strong positive effect on enjoyment, $\beta = .489$, $t = 5.88$, $p < .001$.

RQ1 asked if the virtual reality HMD would have any influence over controller naturalness. An ANOVA was performed; the results found that the presence of the virtual reality HMD had no significant effect on levels of controller naturalness. The standard monitor condition with mouse and key board reported levels of controller naturalness (M=4.07, SD=1.33) that were not significantly different from the virtual reality HMD with mouse and key board condition (M=4.40, SD=1.23), $F_{(3, 203)}$ =3.69, p=1.00. The standard monitor condition with Razer Hydra reported levels of controller naturalness (M=3.89, SD=1.40) that were not significantly different from the virtual reality HMD with Razer Hydra condition (M=3.52, SD=1.36), $F_{(3, 203)}$ =3.69, p=.926.

CHAPTER FIVE

Discussion

This study yielded a mix of expected and unexpected results in regards to how VR HMDs affect spatial presence and enjoyment. The results of H1 indicate that the use of a VR HMD does in fact produce higher levels of spatial presence in users. This is in line with previous presence research on the role of display types in determining levels of spatial presence (Bracken & Skalski, 2006; Skalski & Whitbred, 2010; Hou et al., 2012). How the HMD affected enjoyment however was less clear and highlighted the technical issues of the Oculus Rift prototype used in this study.

Based on results reported by Shafer et al. (2011) it was expected that if a condition yielded higher levels of spatial presence it would also lead to an increase in enjoyment. The initial results did not support this. Enjoyment remained largely the same across all conditions. Results of a regression analysis, however, showed that spatial presence did have a significant positive impact on enjoyment. The reason why this relationship was not seen in the initial analysis was that the covariate negative feelings also had a significant negative impact on enjoyment. These two factors seemed to have canceled each other out, resulting in the appearance that spatial presence had no significant impact on enjoyment.

The prevalence of negative feelings came as a surprise over the course of the study. Many participants were unable to continue playing for the entire session. Participants cited reasons of motion sickness, eye strain and disorientation for why they stopped playing. The data regarding enjoyment shows that negative feelings while using a VR HMD has a significant dampening effect on a user's enjoyment. Although not specifically tied to enjoyment, Merhi et al. (2007) does support the findings of motion sickness being an issue with the use of virtual reality HMDs. Lin et al., (2002), a study also dealing with VR, observed a similar effect of motion sickness dampening the levels player enjoyment.

These negative effects experienced while using the HMD can be attributed to the use of the Oculus Rift prototype. Press sources who have covered the development of the Oculus have often described the negative physical effects they have experienced while using the prototype (Evangelho, 2014; Wasson, 2014). These issues are being resolved however by the continued development and refinement of the Oculus Rift. At the 2014 Consumer Electronics Show (CES) the latest iteration of the Oculus Rift was revealed. Called the 'Crystal Cove', it includes many advancements that alleviate the negative effects experienced in the earlier prototypes (Evangelho, 2014; Wasson, 2014). As virtual reality technology continues to advance, the influence of negative feelings will likely continue to diminish. With these negative feelings no longer present in future iterations, it is possible that these more advanced VR HMDs will show a more clear relationship between spatial presence and enjoyment while using an HMD. Further testing with these new HMDs will be required to verify this assumption. Also of note for future testing are Steuer's (1992) ideas of vividness and interactivity being core components to VR. Studying these concepts now that VR has progressed to an advanced level may yield further understanding of VR environments.

In regards to the controller naturalness portion of the study, expected relationships did not materialize. The Razer Hydra was assumed to be a more natural and more easily understood control type than the mouse and keyboard control type. The results of the study showed otherwise however; the Razer Hydras proved to be less natural for participants, and the mouse and keyboard was judged as a more natural control type. This may be due to technical limitations of the Razer Hydra. Currently an updated version of the Razer Hydra is in development and could potentially be a more natural controller than the current iteration. Another potential explanation for the failings of the Razer Hydra in this study could be found in Vorderer (2000). He argues that as a player becomes more accustomed to the activities needed to control a video game, those activities become more natural and eventually become an unconscious effort to perform. This allows them to experience higher levels of presence in the video game due to needing to dedicate less thought and effort to the act of controlling the game. The interactions required to use the Razer Hydra or even motion controls at large may have been new to participants. Due to this they would need to dedicate thought and attention to understand how to interact with the video game thus limiting their ability to become immersed in the game (Vorderer, 2000).

The goal of this study was to explore new virtual reality HMD technology and to observe if it functioned as expected with regards to existing presence research. The results of the study found that virtual reality technology does indeed have a positive relationship to player presence and potentially to player enjoyment as well. There are still obstacles for virtual reality HMDs to overcome as is evident by the levels of motion sickness experience by players using these HMDs. More testing will be required to verify if the issues found in this study were indeed due to the technical limitations of the displays and controls used. However, as virtual reality technology continues to advance in both display and control technology it is likely that these negative effects will begin to become less prevalent. Currently what is available is just another step along the way to creating truly immersive virtual reality system. What is advancing rapidly, and the potential for future iterations of VR HMDs to revolutionizing gaming is high as the technology is refined.

APPENDIX

Measures

Spatial Presence Subscale of ITC-Sense of Presence Inventory:

1) I felt I could interact with the displayed environment

2) I felt that the characters and/or objects could almost touch me

3) I felt I was visiting the places in the displayed environment

4) I felt I wasn't *just* watching something

5) I had the sensation that I moved in response to parts of the displayed environment

6) I had a sense of being in the scenes displayed

7) I felt that I could move objects (in the displayed environment)

8) I could almost smell different features of the displayed environment

9) I had the sensation that the characters were aware of me

10) I had a strong sense of sounds coming from different directions within the displayed environment

11) I felt surrounded by the displayed environment

12) I felt I could have reached out and touched things (in the displayed environment)

13) I sensed that the temperature changed to match the scenes in the displayed environment

14) I felt that *all* my senses were stimulated at the same time

15) I felt able to change the course of events in the displayed environment

16) I felt as though I was in the same space as the characters and/or objects

17) I had the sensation that parts of the displayed environment
(e.g. characters or objects)were responding to me

18) It felt realistic to move things in the displayed environment

19) I felt as though I was participating in the displayed environment

Negative Effects Subscale of ITC-Sense of Presence Inventory:

1) I felt disorientated

2) I felt tired

3) I felt dizzy

4) I felt I had eyestrain

5) I felt nauseous

6) I felt I had a headache

Klimmt Game Enjoyment Scale:

1) I liked to play the game

2) I found the game entertaining

3) It was great fun to take over the control in the game

4) The game invited me to take control of it

5) the game did not challenge me at all

6) the game was not at all interesting to me

7) I found the game boring

8) I was motivated to participate in the game

Skalski Perceived Controller Naturalness Scale:

1) The game controls seemed natural.

2) The actions used to interact with the game environment were similar to the actions that would be used to do the same things in the real world.

3) The game interface was not realistic.

4) The game environment was manipulated in a lifelike manner.

5) The actions I performed with the controller were closely connected to the actions happening in the game environment.

6) The actions used to control the game seemed natural.

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