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Understanding user experience in gaming

Sri Chaitanya Sanaboina

UNDERSTANDING USER EXPERINCE IN GAMING

by

SRI CHAITANYA SANABOINA

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Dr. Fiona Fui-Hoon Nah
Dr. Keng Siau
Dr. Nathan Twyman

ABSTRACT

This research examines the effect of virtual reality gaming versus desktop based gaming on spatial presence, social presence, and intention to play. It draws on cognitive theory of presence, social presence theory, and theory of reasoned action to generate the research hypotheses and explain the observed phenomenon. A within-subject experimental design (N=53) was used to evaluate the effects of virtual reality versus desktop based gaming. The results suggest that both spatial presence and social presence were significantly enhanced in the virtual reality gaming environment while intention to play was significantly greater in the desktop based gaming environment.

Keywords: Virtual Realty, Spatial Presence, Social Presence, Intention to Play, Cognitive Theory of Presence

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1. INTRODUCTION

In the early 1990's, Virtual Reality (VR) grabbed special attention not only in the field of computer science but also in other disciplines such as communications, media psychology, and media studies (Bracken & Skalski, 2010). Due to advancements in VR technology, the devices are diffusing into homes. Later on, the concept of presence grabbed a lot of attention which led to the development of virtual space and dimensions of virtual space (Seibert, 2014).

According to a report by Newzoo, console games generated a revenue of $26.4 billion dollars in the year 2015 (Sinclair, 2015). Interest in the field of immersive displays and virtual reality environments led to the release of 3D (stereoscopic) movies as well as industry releases such as Oculus Rift by Facebook, Project Morpheus by Sony entertainment, and HoloLens by Microsoft (Kayatt & Nakamura, 2015). Currently, there are different versions of VR headsets such as Oculus Rift, HTC Vive, and Microsoft HoloLens. After that, a new VR headset named Oculus Rift Consumer Version (CV1) developed by Facebook was released into the market where the experience of VR is redefined.

In this research, a laboratory experiment was conducted to understand the effect of desktop vs virtual reality gaming on player experience in terms of spatial presence, social presence, and intention to play in the context of a first person shooter game. Specifically, the interest of this study is to examine if virtual reality in online gaming increases players' sense of spatial presence and social presence, as well as their intention to play the game again.

This paper is organized as follows. First, the literature review is presented which is followed by the theoretical foundation and the hypotheses. Next, the research methodology is described, after which the results are presented and discussed. Finally, the limitations and directions for future research are highlighted.

2. LITERATURE REVIEW

2.1. VIRTUAL REALITY

Recently, there has been a widely expressed interest in the use of VR as a medium for playing games. Advanced technology is used to immerse users in a three dimensional, multisensory VR environment. An example of VR is when users wear a head mounted display along with headphones and use a joystick as a controller. The user's field of real world vision is covered and replaced with the virtual world's visual simulation by the head mounted display helmet. Likewise, headphones can be used to block out external auditory stimuli with audio from the virtual environment. The head mounted display helmet contains a motion tracker that allows head movements in the physical environment to be replicated in the virtual environment. Also, the usage of a joystick allows the user to move around the virtual environment and to interact with virtual items in the environment. Various types of environments are developed for VR, from interacting with gorillas in a jungle habitat to riding down a snow slope and throwing snowballs at snowmen (Kenney & Milling, 2016).

Recently, the market for home entertainment has experienced a revolution in more realistic 3D videos which are readily available at a lower price. Likewise, new lines of production in video games and 3D televisions have entered into the home market. Such 3D graphics can enhance the vividness and perceptual realism experienced in a game. Perceptual realism, which shows how perceptually real mediated environments appear, can generate what was called "presence as realism" (Lombard & Ditton, 1997). A study demonstrated that the realism generated by advancements of video game technology led to a greater feeling of presence (Ivory & Kalyanaraman, 2007). Steuer (1992) argued that the capability of a technology to create presence depends on two factors: vividness and interactivity. Vividness refers to the representational richness of a mediated environment in terms of its formal features or the way in which information is presented to the senses (Steuer, 1992). Steuer (1992) further conceptualizes vividness in terms of sensory breadth (i.e., number of sensory dimensions simultaneously presented) and sensory depth (i.e., resolution within each of the perceptual channels). Vividness is also referred to as the capability of a technology to create a sensory rich mediated environment that could have effects on presence (Williams, 2014). Interactivity refers to the extent to which the form and content of a mediated environment can be modified in real time (Steuer, 1992). Steuer (1992) conceptualizes interactivity as comprising three factors: speed or response time (i.e., the rate of assimilation of input in the mediated environment), range (i.e., the number of attributes of the mediated environment that can be manipulated and the degree of variations within each attribute), and mapping (i.e., the degree to which the controls map to changes in the mediated environment in a natural and predictable manner).

Presence has been defined in various ways. In short, presence is the sense of being located in a mediated environment (Williams, 2014). Lee (2004) defined presence as a psychological perception where virtual objects are experienced as real objects in either sensory or non-sensory ways. Presence is also defined as the degree to which individuals feel present in a mediated environment instead of the actual physical environment (Steuer, 1992). The International Society of Presence Research describes presence as a multi-dimensional concept that includes telepresence and social presence. This society also argues that presence can be separated into those that relate to the sense of physical environments, sense of social interactions, and both physical environments and social interactions. The present study examines the sense of the physical environment, or more specifically, the concepts of spatial presence and social presence (Williams, 2014).

2.2. PRIOR RESEARCH ON SPATIAL PRESENCE

Most of the current research that has been carried out to study presence investigated spatial presence, which is also referred to as telepresence. Spatial presence is defined as the user's subjective experience that he or she is being physically present in a mediated environment (Sacau et al., 2008). Spatial presence is also defined as a sense of illusion that makes the individual think that the environment is non-mediated (Lombard & Ditton, 1997). Though the belief that spatial presence depends on the characteristics of the technology still exists, the literature on spatial presence has increasingly placed more importance on subjective psychological factors (Williams, 2014).

Spatial presence is specifically related to the technologies designed to produce immersive media experiences, such as film, TV, and video games. In fact, technological developments such as high definition images (Bracken & Campanella, 2005; Bracken et al., 2010), larger screens (Kim & Sundar, 2013; Lombard et al., 2000) and stereoscopic 3D images (W. IJsselsteijn et al., 1998; W. A. IJsselsteijn et al., 2001) enhance spatial presence compared with technologies that are less immersive (Lull & Bushman, 2014).

2.3. PRIOR RESEARCH ON SOCIAL PRESENCE

Social presence is considered one of the important aspects by scholars studying virtual environments (Axelsson et al., 2001; Hoyt et al., 2003; Slater et al., 2000). Social presence has been defined as the feeling of being with other people in a mediated environment (Biocca et al., 2001; Shen & Khalifa, 2008). Social presence represents the users' sense of communicating or interacting with other entities or people in the mediated environment (Choi et al., 2001). Although there seems to be no established antecedents of social presence, many researchers agreed that social cues provided by a system and information about social interactions with other users are related with social presence (Lee et al., 2012).

Lombard and Ditton (1997) classified presence into six dimensions: social richness, realism, transportation, immersion, social actor within medium, and medium as social actor. Social richness refers to the degree to which a medium is perceived as sociable, intimate, and personal. Realism refers to the degree to which a medium is able to produce representations that are seemingly accurate and real. Transportation can take place when (i) users are being brought or transported to another environment, (ii) objects in an environment along with the environment are being brought or transported to the user, or (iii) users and the virtual environment (and/or objects in the environment) are being transported together to a shared environment. Immersion refers to the perceptual and psychological sense of being submerged in a virtual environment. Presence as 'social actor within medium' refers to the perception of interacting with social actors in a virtual environment, whereas presence as 'medium as social actor' refers to social responses to cues provided by the medium rather than to entities (i.e., people or computer agents) within the medium.

According to the social richness dimension, individuals assess the abilities of a medium to convey social presence. Additionally, presence as 'social actor within medium' enhances social presence. Therefore, social presence refers to the degree of sociability, personalness, and emotional contact conveyed by an environment and the actors within the environment.

Previous studies have examined social presence in terms of media features (Lombard & Ditton, 1997). Most of the previous research on virtual environments tend to emphasize the technological features of an environment in creating social presence. In virtual environments, using avatars and displaying individual’s online status could induce social presence (Shen & Khalifa, 2008). The use of verbal and nonverbal communication media and the use of avatars make it easier for individuals to connect both psychologically and socially (Bulu, 2012).

3. THEORETICAL FOUNDATION AND HYPOTHESES

The aim of this research is to understand user experience in VR gaming. To generate hypotheses for this research, cognitive theory of presence, social presence theory, and theory of reasoned action are used to explain spatial presence, social presence, and intention to play.

3.1. COGNITIVE THEORY OF PRESENCE

Cognitive theory of presence focuses on spatial presence and discusses two cognitive steps during its formation (Wirth et al., 2007). During the first step, user attention is allocated among the stimuli in a virtual environment which in turn creates a simulated spatial mental model that is called the spatial situation model. Media richness and vividness influence the allocation of attention during the formation of the spatial situation model. In the second step, individuals must accept or reject this spatial situation model as their own egocentric frame of reference or point of view. If accepted, spatial presence is said to have been created for the individual; if rejected, the real world's mental model remains as the individual's primary frame of reference. Interactivity and persistence are the media factors that affect the acceptance of the spatial situation model as the primary reference frame. Although it is not explicitly stated, cognitive theory of presence strongly stresses that both the formation and acceptance of the primary egocentric reference frame are unconscious processes of spatial cognition (Wirth et al., 2007).

As mentioned earlier, according to Steuer (1992), vividness has two dimensions: (i) breadth and (ii) depth. Breadth refers to the number of sensory perception channels which can be presented simultaneously. For example, video has greater depth when compared to audio. Depth refers to the quality and quantity of the perceptual channels. For instance, a high definition (HD) medium has greater depth than an ordinary quality medium (Cheng et al., 2014). Steuer (1992) described interactivity as the “extent to which users can participate in modifying the form and content of a mediated environment in real time” (p.75). Previous studies on interactivity recognized three major means of abstracting interactivity, i.e., the views of telepresence, process, and perception (McMillan & Hwang, 2002).

Previous research suggests that interactivity and vividness influence presence (Klein, 2003). Furthermore, studies found that environments which have more vividness and media richness impact the presence level perceived in virtual environments (Fortin & Dholakia, 2005; Li et al., 2001; Welch et al., 1996). As discussed earlier, media richness and vividness can help in the formation of the spatial situation model, which is an antecedent of spatial presence. To enhance vividness, tools that are rich in media such as audio, visualization, and animation can help to increase the richness of the experience. According to Rothschild (1987) as well as Zeff and Aronson (1999) , attention can increase when animations are used effectively.

Researchers have studied presence from the perspective of interactivity. For instance, Shih (1998) stated that the user’s interaction and the feedback received from the environment can have an effect on the user’s sense of presence. Hoffmann and Novak (1999) stated that, through constant feedback and response, presence can be enhanced. Studies also have found that the capability to respond quickly enhance one’s online presence (Amant, 2002; Animesh et al., 2011). Spatial presence occurs if an individual experiences the sense of being located in a mediated environment and the sense of being able to take actions within the mediated environment. Spatial presence is expected to exist in the context of VR environments or video games, but to a lesser extent within films or books (Weibel et al., 2015; Wirth et al., 2007).

3.2. SOCIAL PRESENCE THEORY

Social presence refers to the "feeling of being with one another" (Biocca et al., 2003, p.456). It is mainly used to sense the presence of other people in distant locations. Lombard and Ditton (1997) referred to social presence as "social richness" which is considered as another aspect of presence. Social richness is defined as the degree to which a medium is observed as sociable, warm, sensitive, personal, or intimate, and it is used to interact with other characters or people. Several information systems and organizational behavior research has examined the concept of presence, particularly social presence theory (Biocca et al., 2003) and media richness theory (Daft & Lengel, 1983; Rice, 1992).

Media richness theory (Daft & Lengel, 1983) and theory of social presence (Short et al., 1976) indicate that presence is dependent upon the basis of the technology. In social presence theory, to convey socially richer information, the technologies are ranked according to their capacity to transfer information on expressions, gestures, and audio output, all of which create the sense of social presence. In media richness theory, different technologies are classified on the basis of immediate feedback, nonverbal back-channeling cues, personalization, and language variety. The theory proposes that a virtual environment is socially rich when compared to a lean medium. For example, an e-mail is not a rich medium because it has limited capacities to convey social presence. From the perspective of media richness theory, social presence is highly dependent on technologies (Bulu, 2012).

Several theories, including social presence theory, can help to explain what makes a technology seem more human-like. Social presence is "the degree of salience of the other person in a mediated communication and the consequent salience of their interpersonal interactions" (Short et al., 1976, p. 65). Social presence theory posits that the attributes of a technology influence whether it is perceived as being more sociable, warm, and personal than other technologies based on the extent to which it allows a user to experience other individuals as being psychologically present. Researchers have used social presence in two distinct ways: (1) to refer to a property of a medium in a mediated communication, and (2) to refer to participants’ perceptions, behavior, or attitudes in mediated interactions (Gunawardena, 1995; Rettie, 2003). Rettie (2003) explained that social presence can be considered a property of the medium and is also related to a property of perception or interaction because the characteristic of a medium is derived from the effect of the medium on the participants’ perceptions and interpersonal interactions.

Since the development of social presence theory, researchers have used it to study computer mediated communication and online learning (Qiu & Benbasat, 2009). Qiu and Benbasat (2009) have used the theory to examine how people are connected to other people through technology and how people interact with technology. Researchers have also used social presence theory to investigate online marketing and e-commerce websites (Gefen et al., 2003; Kumar & Benbasat, 2006). Much of this research has examined the ways in which social presence can be enhanced. For example, IS researchers have found that one can increase individual perceptions of social presence with socially rich text content and personalized greetings (Gefen et al., 2003), emotive text and human images (Cyr et al., 2009), live chat and online reviews (Cyr et al., 2007), interactivity and voice (Wang & Benbasat, 2007), humanoid embodiment and human voice-based communication (Qiu & Benbasat, 2009).

3.3. THEORY OF REASONED ACTION

The theory of reasoned action (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975) states that behavioral intention is an antecedent of behavior. There are two belief antecedents of behavioral intention: behavioral beliefs and normative beliefs. Behavioral beliefs are the main cause of influencing an individual's attitude toward a behavior. Normative beliefs are the cause of influencing an individual's subjective norm regarding the behavior. Thus, these salient beliefs influence subsequent behavior and intentions through attitudes and/or subjective norms.

Fishbein and Ajzen (1975) identified three boundary conditions which have an effect on the magnitude of the relationship between intention and behavior. The boundary conditions are: (a) the extent to which the behavioral criterion and the measure of intention correspond with the levels of specificity, (b) the stability intentions between performance of behavior and time of measurement, and (c) the extent to which an individual has volitional control to carry out the behavior.

As per the theory of reasoned action, behavioral intention is the user's self-evaluated likelihood of performing an action (Ajzen, 1985). This theory has been widely used in extending the technology acceptance model to explain behavioral intention to use or to accept a particular technology (Davis et al., 1989; Hsu & Chiu, 2004). Furthermore, behavioral intention is often used to evaluate an individual's intention to reuse the technology in the future (Choi, Lee, & Kim, 2011; Lee et al., 2012).

3.4. HYPOTHESIS GENERATION

This section will draw on the theoretical foundation reviewed earlier to generate hypotheses for this research. In this study, virtual reality is the independent variable whereas spatial presence, social presence and intention to play are the dependent variables.

3.4.1. Virtual Reality and Spatial Presence. VR environments deliver rich media with a high volume of content and representational quality. The sensory breadth and depth of an interface can determine the degree of media richness (Steuer 1992). Depth refers to the quality of information within each channel. VR environment enhances sensory depth, specifically from the visual sense perspective, as it can represent more details through the perceived depth afforded by the VR environment. Similarly, in a VR environment, the sensory breadth is also wider as the VR environment offers a 360 degree view as compared to a static or traditional view. Given that VR games are richer in media than desktop based games, vividness is higher in VR games compared to desktop games. Hence, VR gaming facilitates the creation and perception of a spatial situation model. As discussed in cognitive theory of presence, the formation of the spatial situation model is one of the factors that create and enhance spatial presence. Therefore, vividness is higher in VR games, and thus players experience higher levels of spatial presence.

Hence, the following hypothesis is proposed:

H1: Virtual reality increases spatial presence.

3.4.2. Virtual Reality and Social Presence. Given that VR increases the richness of a medium in terms of its depth and breadth, a player in the VR gaming environment can become more aware of other players in the environment because of the increased sense of presence afforded by the richer medium. Thus, in the VR gaming environment, vividness helps to enhance players' perception of other characters as real because the VR medium generates more realistic environment when compared to the desktop gaming (Schroeder, 2012). As a consequence, one of the dimensions of social presence, the degree of contact, is higher due to higher realism in VR games. Therefore, VR games can enable players to experience a higher sense of social presence than desktop games. Hence, the following hypothesis is proposed:

H2: Virtual reality increases social presence.

3.4.3. Virtual Reality and Intention to Play. Given that the VR environment affords a richer medium for game play, the experience of being engaged in the game or simply having fun would have an impact on intentions to play the game again in the VR environment. Previous studies have shown that virtual environments which are more vivid influence the presence level in the virtual environments (Fortin & Dholakia, 2005; Li et al., 2001; Welch et al., 1996). Arguably, vividness influences behavioral intentions toward a specific task. As vividness is higher in the VR environment, players' behavioral intention of playing a game will be positively influenced by VR. Hence, the following hypothesis is proposed:

H3: Virtual reality increases intention to play.

4. RESEARCH METHODOLOGY

4.1. EXPERIMENTAL DESIGN

In this study, a within-subject experimental design was used. The independent variable, VR versus desktop-based environment, is a within-subject factor, where desktop-based environment served as the control condition. A within-subject factor is one where each subject experiences all levels of that factor. Since one of the goals of this study is to assess the effect of desktop-based versus VR game playing experience, it is more appropriate to operationalize VR as a within-subject factor so subjects serve as their own control. In order to remove any potential ordering effects, counterbalancing was used on the order of these two game playing experiences in which the first experimental condition alternated between the desktop and VR condition for every subsequent subject in the study.

After a comprehensive review and thorough search of first person shooter games, Counter-Strike was identified as an appropriate game that fits the research purpose. The reasons for choosing this game are: (1) it has the ability to support the same game in two different environments i.e., Counter-Strike has the flexibility to support both desktop and VR versions through a third-party software called VorpX, and (2) it has the option to select or specify the difficulty level.

4.2. RESEARCH PROCEDURES

This research study was conducted in a university computer lab. The research procedures are as follows: The subjects were asked to fill out a pre-study questionnaire to capture their visual spatial imagery (see Table 4.1) and immersive tendencies (see Table

4.2) at the beginning of the experiment. They were then provided with training on the game, Counter-Strike. An Xbox controller was used to control the game in both the desktop-based and VR conditions. A cheat sheet that shows the basic commands of the game was provided to the subjects (Appendix A). The subjects were given a 5-minute training session to practice playing Counter-strike with the Xbox controller.

Next, based on the gaming condition assignment, the subjects completed a 5-minute training session to practice playing Counter-strike with the specified console (i.e., desktop or VR) after it has been introduced to them (Appendix B or D). They then read instructions about gaming session 1 (Appendix C or E), which is the first experimental condition they were assigned to. They were then given 10 minutes to play the game in the assigned condition (i.e., desktop or VR) and filled out a questionnaire after gaming session 1. After the subjects completed gaming session 1 and the questionnaire that followed, they were given a short break before completing a second training session of 5 minutes using a different console (i.e., desktop or VR) from the earlier training session. After a short break, they were asked to read the instructions for the second training session (Appendix B or D). . Next, they read the gaming instructions for gaming session 2 (Appendix C or E) and were given 10 minutes to play gaming session 2 using the console. They also filled out a questionnaire after completing gaming session 2.

In short, some subjects were assigned to play the desktop version of the game followed by the Oculus Rift version of the game, whereas other subjects were assigned to the Oculus Rift version of the game followed by the desktop version of the game. After playing each session, they filled out a questionnaire to assess their sense of social presence, spatial presence, and intention to play. As indicated above, the Oculus Rift (https://www.oculus.com/) was used to operationalize the VR condition whereas a traditional desktop and monitor (17 inch) was used to operationalize the desktop (control) condition.

4.3. MEASUREMENT

The pre-study questionnaire was used to assess the subjects' visual spatial imagery ability and immersive tendencies, and the post-study questionnaire to assess social presence, spatial presence, intention to play, and the background and demographic information of the subjects.

4.3.1. Visual Spatial Imagery. The visual spatial imagery scale was used to assess the ability to visualize spatial images (see Table 4.1 for the items). The measurement scale for visual spatial imagery was adopted from (Vorderer et al., 2004). The 7-point Likert scale (strongly disagree = 1 to strongly agree = 7) was used.

Table 4.1. Measurement Scale for Visual Spatial Imagery

	Measurement Items
Visual Spatial Imagery	(VSI1) When someone shows me a blueprint, I am able to imagine the space easily.
	(VSI2) It is easy for me to negotiate a space in my mind without actually being there.
	(VSI3) When someone describes a space to me, it is usually very easy for me to imagine it clearly.

4.3.2. Immersive Tendencies. The immersive tendencies scale was used to assess the general tendency to be immersed in various tasks and surroundings (see Table 4.2 for the items). The measurement scale for immersive tendencies was adopted from Gerhard et al. (2004). The 5-point Likert scale (not at all = 1 to very great extent = 5) was used.

Table 4.2. Measurement Scale for Immersive Tendencies

	Measurement Items
Immersive Tendencies	(IM1) Do you become so involved in a game, book, TV or movie to the extent that you are not aware of things happening around you and people have problems getting your attention?
	(IM2) To what extent do you find yourself closely identifying with the characters in the story line of a game, book, television program or movie?
	(IM3) How good are you at blocking out external distractions when you concentrate on a task?
	(IM4) When reading a good book, watching a good movie or playing a computer game, do you feel the emotions of the story such as sadness, fear, or joy?

4.3.3. Spatial Presence. The measurement scale for spatial presence was adopted from Vorderer et al. (2004) for assessing the subjective experience of spatial presence (see Table 4.3). The items included “I felt like the objects in the virtual environment surrounded me in the last round of game play” and “It seemed as though I actually took part in the action in the last round of game play.” The 7-point Likert scale (strongly disagree = 1 to strongly agree = 7 was used.

Table 4.3. Measurement Scale for Spatial Presence

	Measurement Items
Spatial Presence	(SPAT1) I felt like the objects in the virtual environment surrounded me in the last round of game play.
	(SPAT2) It was as though my true location had shifted into the virtual environment in the last round of game play.
	(SPAT3) It seemed as though I actually took part in the action in the last round of game play.
	(SPAT4) I felt like I could move around the objects in the last round of game play.
	(SPAT5) The objects in the virtual environment gave me the feeling that I could interact with them in the last round of game play.

4.3.4. Social Presence. The measurement scale for social presence was adopted from Gefan & Straub (2003) for assessing the subjective experience of social presence (see Table 4.4). For these items, a 7-point Likert scale (strongly disagree = 1 to strongly agree = 7) was used.

Table 4.4. Measurement Scale for Social Presence

	Measurement Items
Social Presence	(SP1) There was a sense of human contact in my last round of game play.
	(SP2) There was a sense of personalness in my last round of game play.
	(SP3) There was a sense of sociability in my last round of game play.

Table 4.4. Measurement Scale for Social Presence (cont.)

Social Presence	(SP4) During my last round of game play, my interaction with other players was emotional.

4.3.5. Intention to Play. The measurement scale for intention to play was adopted from Agarwal & Karahanna (2000), and Nah et al. (2011) (see Table 4.5 for the items). The 7-point Likert scale (strongly disagree = 1 to strongly agree = 7) was used.

Table 4.5. Measurement Scale for Intention to Play

	Measurement Items
Intention to Play	(INT1) Based on my last round of game play, I would play this game using the same setup/configuration in the future.
	(INT2) Based on my last round of game play, it is likely that I will play this game using the same setup/configuration in the future.
	(INT3) Based on my last round of game play, I intend to play this game using the same setup/configuration in the future.

4.3.6. Subject Background Questionnaire. The background questionnaire (see Appendix F) included participant demographics (e.g., gender, age, education), and gaming habits (e.g., how often participants play games and the number of hours per week spent playing games).

4.4. PILOT TESTS

Two pilot studies were conducted to test the instruments, the game software, and the experimental procedures. The first pilot study was used to fine-tune and assess the measurement items, where items that did not load well were dropped from the study. The second pilot study was used to fine-tune the experimental setup, procedures, and gaming software. Based on feedback from the pilot studies, adjustments were made to the measurement items, experimental procedures, and the gaming software. For example, more refined and clear instructions about the procedures were provided in Qualtrics, particularly in switching between the gaming sessions and the questionnaires. Also, the time frame for each training session was reduced from 10 minutes to 5 minutes and the time frame for each gaming session from 15 minutes to 10 minutes because the experiment took more than 1.5 hours, which was too long for the subjects.

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5. DATA ANALYSIS

Subjects were graduate and undergraduate students from Missouri University of Science & Technology. This study was limited to only male subjects in order to control for gender. Participants were recruited through social networks, forums, and email contact.

Sixty subjects participated in the study but only 53 participants successfully completed the experiment. Hence, the sample size for the study is 53. The ages of the subjects are between 18 and 39. Demographic information of the subjects is summarized in Table 5.1. Descriptive statistics for visual spatial imagery and immersive tendencies are provided in Table 5.2 and Table 5.3 respectively. Factor analysis and validity checks on the measurement scales were conducted. SPSS 11.0 software was used to analyze the data collected, and the statistical tests were assessed at the 0.05 significance level.

Table 5.1. Summary of Demographic Information of Subjects

Age	
18-24	67.9%
25-29	28.3%
30-34	1.9%
35-39	1.9%
40 or above	0.0%
Education	
Less than high school	0.0%
High school graduate or equivalent	28.3%
Associate degree or equivalent	13.2%
Bachelor's degree	39.6%
Post graduate degree	18.9%
Computer gaming experience (Total no. of years)	
< 1 year	5.7%
1 - 3 years	7.5%

Table 5.1. Summary of Demographic Information of Subjects (cont.)

3 - 6 years	17.0%
6 - 10 years	34.0%
> 10 years	35.8%
First-person shooter game experience (Total no. of hours/week)	
Never played it before	9.4%
< 10 hours	66.0%
11 - 20 hours	20.8%
21 - 30 hours	3.8%
> 30 hours	0.0%
Counter-Strike gaming experience (Total no. of years)	
< 1 year	60.4%
1 - 3 years	13.2%
3 - 6 years	11.3%
6 - 10 years	9.4%
> 10 years	5.7%

Table 5.2. Descriptive Statistics for Visual Spatial Imagery

	N	**Mean**	**Std. Deviation**	**Minimum**	**Maximum**
VSI1	53	5.55	.952	3	7
VSI2	53	5.28	1.231	2	7
VSI3	53	5.13	1.373	1	7

Table 5.3. Descriptive Statistics for Immersive Tendencies

	N	**Mean**	**Std. Deviation**	**Minimum**	**Maximum**
IM1	53	3.32	.996	1	5
IM2	53	3.38	1.130	1	5
IM3	53	3.47	1.067	1	5
IM4	53	3.62	.985	1	5

5.1. MEASUREMENT VALIDATION

Exploratory factor analysis (EFA) was conducted to evaluate convergent and discriminant validity for the constructs in the survey questionnaire. EFA results with varimax rotation and principal component analysis are reported in Table 5.4 for the desktop condition and in Table 5.5 for the virtual reality condition. A three-factor structure was identified with eigenvalues greater than 1.0. All the measurement items loaded onto their target factors and scored above 0.603 for the desktop condition and above 0.672 for the virtual reality condition, which suggests good construct validity (Cook, Campbell, & Day, 1979).

The Cronbach's alpha coefficient (Cronbach, 1951) was used to assess the reliability of the measurement. The Cronbach's alpha coefficients for spatial presence are 0.85 for the desktop condition and 0.89 for the VR condition. The Cronbach's alpha coefficients for social presence are 0.86 for the desktop condition and 0.91 for the VR condition. The Cronbach's alpha coefficients for intention to play are 0.97 for the desktop condition and 0.98 for the VR condition. A value of at least 0.70 indicates adequate reliability (Nunnally et al., 1967). The Cronbach's alpha coefficients for all constructs were well above 0.7, which indicates that all the measurement items achieved high reliability.

5.2. QUANTITATIVE ANALYSIS

Spatial presence, social presence, and intention to play are within-subject factors, and hence, the paired t-test was used to analyze them. The descriptive statistics are provided in Table 5.6.

Table 5.4. Results of Factor Analysis for Desktop

	Component		
	1	2	3
DES_SPAT5	.867	.179	.113
DES_SPAT4	.832	.066	.221
DES_SPAT2	.715	.442	.134
DES_SPAT3	.672	.205	.047
DES_SPAT1	.603	.334	.086
DES_SP2	.158	.814	.276
DES_SP4	.188	.798	.179
DES_SP3	.305	.792	.085
DES_SP1	.305	.724	.233
DES_INT3	.149	.220	.940
DES_INT2	.156	.209	.939
DES_INT1	.128	.189	.922
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.			

Table 5.5. Results of Factor Analysis for Oculus

	Component		
	1	2	3
O_SPAT1	.848	.115	.168
O_SPAT2	.816	.202	.075
O_SPAT3	.804	.315	.098
O_SPAT4	.690	.366	-.009
O_SPAT5	.672	.441	.253
O_SP4	.158	.851	.076
O_SP2	.281	.836	.120

Table 5.5. Results of Factor Analysis for Oculus(cont.)

O_SP1	.319	.824	.126
O_SP3	.343	.823	.143
O_INT3	.148	.086	.967
O_INT2	.112	.128	.967
O_INT1	.094	.147	.965
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.			

Table 5.6. Descriptive Statistics

		N	Mean	Std. Deviation	Std. Error
Spatial Presence	Desktop	53	3.87	1.31	0.180
	Virtual Reality (Oculus)	53	5.14	1.22	0.167
Social Presence	Desktop	53	3.44	1.38	0.189
	Virtual Reality (Oculus)	53	4.15	1.53	0.210
Intention to Play	Desktop	53	4.92	1.74	0.239
	Virtual Reality (Oculus)	53	3.94	2.02	0.278

5.2.1. Spatial Presence. Subjects in the VR condition (M = 5.14, SD = 1.22) experienced greater spatial presence in the game than subjects in the desktop condition

(M = 3.87, SD = 1.31) condition (see Table 5.6). A significant effect was found on spatial presence, i.e., $p = 0.000$ (<0.05) (see Table 5.7).

5.2.2. Social Presence. Subjects in the VR condition (M = 4.15, SD = 1.53) experienced greater social presence in the game than subjects in the desktop condition (M = 3.44, SD = 1.38) (see Table 5.6). A significant effect was found on social presence, i.e., $p = 0.001$ (<0.05) (see Table 5.7).

5.2.3. Intention to Play. Subjects in the VR condition (M = 3.94, SD = 2.02) indicated lower intentions to play the game again using the same configuration console setup than subjects in the desktop condition (M = 4.92, SD = 1.73) (see Table 5.6). A significant effect was found on intention to play, i.e., $p = 0.008$ (<0.05), but in the opposite direction from what was hypothesized (see Table 5.7).

Table 5.7. Paired Samples T-tests

	t	**df**	**Sig. (2-tailed)**
Desktop_Spatial Presence – Oculus_Spatial Presence	-6.511	52	0.000
Desktop_Social Presence – Oculus_Social Presence	-3.697	52	0.001
Desktop_Intention to Play – Oculus_ Intention to Play	2.760	52	0.008

Table 5.7 shows the results of hypothesis testing. H1 (Virtual Reality → Spatial Presence) and H2 (Virtual Reality → Social Presence) are supported, suggesting that the VR environment leads to greater spatial presence and social presence than the desktop

environment. H3 (Virtual Reality → Intention to Play) is not supported, suggesting that intentions to play the game are not higher for the VR environment than the desktop environment. Interestingly, the results show that intentions to play the game are higher for the desktop environment than the VR environment. The results are presented in Table 5.8.

Table 5.8. Results of Hypothesis Testing

Hypothesis	Supported?
H1: Virtual reality leads to spatial presence	Yes
H2: Virtual reality leads to social presence	Yes
H3: Virtual reality leads to intention to play	No

5.3. QUALITATIVE ANALYSIS

After the experiment, a short interview was conducted with the participants. Among the 53 participants, 32 of them (60%) felt discomfort while using Oculus Rift. 42 of them indicated that they prefer to play the desktop version of the Counterstrike game.

The most common issues that were reported with the use of Oculus Rift are:

1. Body is stationary which created motion sickness. In the experiment, the chair was stationary and the head has to move around to view the surroundings in the VR. Since there was a mismatch of coordination for the body (which is stationary) and the mind (which feels like moving in the VR environment), it caused motion sickness.
2. Feelings of dizziness and/or nausea. Some participants (i.e., 7 of them) could not complete the study due to dizziness that was caused by the Oculus Rift.

3. Poor VR performance of Oculus development kit 2 (DK2). The output from the Oculus DK2 is somewhat blurry and the players were not able to view the entire screen. It is due to the development kit used in the experiment where the technology is still pre-mature and limited in functionality. For example, it could not produce a map of the game properly for the players.

   Some of the comments given by the participants on the Oculus Rift are listed below:

- "The oculus rift gave me a dizzy feeling. I felt the motion sickness and got the feeling that we get while we fly in plane or in ship. It creates motion sickness. I would not prefer playing on rift".
- "The last round was good, but it felt uncomfortable to play with the heavy set up on and also felt uneasy."
- "The oculus rift was cool to use but I couldn't play that well because it distorted my vision a little bit.”
- "When the game ended, I felt that I just woke up from a dream. I felt a little discomfort at the beginning but gradually got used to the game."

6. DISCUSSIONS

The findings from this study suggest that VR games induce a greater sense of spatial presence and social presence than desktop games. The findings also suggest that players have greater intentions to play desktop games than VR games. Secondary analysis is conducted to assess whether player enjoyment was higher when playing desktop games or VR games, and found that enjoyment was higher with desktop games than VR games ($p<0.05$). The results for the study are further discussed below.

First, spatial presence is significantly increased by using VR games. Cognitive theory of presence states that players experience more spatial presence if the spatial situation model can be formed. The findings from this study are in line with cognitive theory of presence, which posits that VR leads to spatial presence. This finding is also in line with past studies on the importance of the types of display, like the VR head mounted display, in determining spatial presence (Bracken & Skalski, 2006; Hou et al., 2012; Seibert, 2014; Skalski & Whitbred, 2010).

Second, social presence is significantly increased by VR games. As put forth by social presence theory, media richness can induce social presence (Biocca et al., 2003). This finding is consistent with social presence theory, which posits that virtual reality generates greater feelings of social presence.

Lastly, intention to play is not significantly increased by VR games. Instead, the reverse relationship is observed. As mentioned earlier, secondary analysis was conducted to assess player enjoyment, and found that enjoyment was higher for the desktop game than the VR game. Possible reasons that participants prefer the desktop game to the VR game include:

- Counterstrike is typically played on a desktop with the keyboard and the mouse, and hence, the switch to Oculus Rift could create a switching cost and a learning curve.
- Oculus Rift caused some discomfort and motion sickness during the game which could have created a negative opinion on the device.

7. LIMITATIONS AND FUTURE RESEARCH

This study has some limitations, which can be resolved in subsequent or future research. First, this study was limited to only male participants. The reason for doing so was because Counter-Strike, a first person shooter game, was utilized, and generally, first-person shooter games are played largely by males. Hence, females were omitted in order to prevent the results from being skewed by an audience group that is largely unfamiliar with the game. Future studies can overcome this limitation by choosing a game that is generally played by both gender groups.

Second, many participants felt discomfort during the experiment. Participants cited reasons such as dizziness, motion sickness, and nausea. The qualitative study conducted after the experiment in which were interviewed indicates that the poor performance of Oculus Rift DK2 imposed discomfort to the participants. Future studies should try to use the updated version of Oculus Rift (CV1), which is a more recent and mature technology for VR, to test the players' experience.

Third, although the relationship between VR and spatial and social presence was assessed, the key factor (i.e., vividness) that is expected to produce the effects was not captured or assessed. Future studies could capture vividness and validate if the effect of VR on spatial and social presence arises from the vividness dimension of VR.

8. CONCLUSIONS

In conclusion, this study investigates the role of VR games on spatial presence, social presence, and intention to play the game again. Based on cognitive theory of presence, social presence theory, and theory of reasoned action, this study focuses on understanding spatial presence, social presence, and intention to play in the context of VR games. The findings suggest that VR is an important factor that enhances spatial presence and social presence in games. In other words, both spatial presence and social presence are comparatively higher in VR (Oculus Rift) than in non-VR (desktop) gameplay. In sum, this study offers key insights on two types of presence experiences, spatial presence and social presence, and how VR can change such gaming experiences.

This research contributes to developing a greater understanding of players' spatial presence and social presence experiences in the VR context. The findings can benefit game developers by providing them with a better understanding of how the VR context affects players' experience. The effect of VR on intention to play the game was also assessed, and hence, this research offers insights on the impact of different game play conditions on players' intention to play.

APPENDIX A.
COUNTER-STRIKE GAME COMMANDS

Instruction	**Button**
Fire	RT
Alternate fire	RS
Reload	B
Jump	A
Duck	LT
Use	X
Move	Left stick
Look around	Right stick
Spin 180	RB
Swap primary	Y
Select grenade/bomb	LB

APPENDIX B.

PRACTICE INSTRUCTIONS FOR DESKTOP

Welcome to this session where you will be playing a computer game, Counter Strike. We thank you and appreciate your participation and attendance. Our interest is to study game-playing experience to improve the design of computer games. Hence, you have been invited to play the game that includes two sessions. You will first begin with a practice session described below.

The following information pertains to the practice session and instructions on how to play the game. The training you receive in this practice session is critical for your successful participation in the experiment. Please read the instructions carefully and make sure you understand them before you start. If you have any questions, ***please raise your hand***.

- You will be given 5 minutes to familiarize with the game.
- After 5 minutes, your session will be stopped by the researcher.
- In the game, Counter Strike, you will be a member of Counter Terrorist forces. Your objective is to defuse the bomb planted by terrorists in one of the designated spots (A or B) before it explodes. <u>When a bomb explodes, you lose the game</u>.

APPENDIX C.

GAMING SESSION INSTRUCTIONS FOR DESKTOP

Now, we will start gaming session 1. Please take this session seriously and follow the instructions carefully as they can have important consequences for our understanding of your game-playing experience.

OBJECTIVE/GOAL: Your task during this session is to ***play the game on desktop*** by taking the role of a counter terrorist.

- After 10 minutes, your session will be stopped by the researcher.
- Fill out the post-study questionnaire in the Qualtrics window based on your experience in this session.

APPENDIX D.

PRACTICE INSTRUCTIONS FOR OCULUS (VIRTUAL REALITY)

The following information pertains to the practice session and instructions on how to play the game using *Oculus Rift*. The training you receive in this practice session is critical for your successful participation in the experiment. Please read the instructions below and information on "Health and Safety Warnings" carefully and make sure you understand them before you start. If you have any questions, ***please raise your hand***.

- Once you are ready, researcher will help you in setting up Oculus Rift.
- Oculus Rift is a head-mounted display that you need to wear during this session and play Counter-Strike
- Whenever you put on your Rift headset, you're entering the virtual reality (VR) environment. Here's how to get around in VR.
    1. To change what you're seeing, just move your head.
    2. While playing the game, you'll see a pointer at the center of your field of view, which can help you shoot the targets more precisely.
- You will be given 5 minutes to familiarize with the game *using Oculus Rift*.
- After 5 minutes, your session will be stopped by the researcher.
- Your objective is to defuse the bomb planted by terrorists in one of the designated spots (A or B) before it explodes. <u>When a bomb explodes, you lose the game</u>.

Health & Safety Warnings

- ➢ We recommend not to participate if you are pregnant, elderly, have pre-existing binocular vision abnormalities or psychiatric disorders, or suffer from a heart condition or other serious medical condition.

- Some people (about 1 in 4000) may have severe dizziness, seizures, epileptic seizures or blackouts triggered by light flashes or patterns, and this may occur while they are experiencing virtual reality, even if they have never had a seizure or blackout before or have no history of seizures or epilepsy. We recommend not to participate in any of such instances.
- The headset produces an immersive virtual reality experience that distracts you from and completely blocks your view of your actual surroundings. Always be aware of your surroundings when using the headset and **remain seated at all times**.
- Immediately **raise your hand** if anyone using the headset experiences any of the following symptoms: seizures; loss of awareness; eye strain; eye or muscle twitching; involuntary movements; altered, blurred, or double vision or other visual abnormalities; dizziness; disorientation; impaired balance; impaired hand-eye coordination; excessive sweating; increased salivation; nausea; lightheadedness; discomfort or pain in the head or eyes; drowsiness; fatigue; or any symptoms similar to motion sickness

APPENDIX E.

GAMING SESSION INSTRUCTIONS FOR OCULUS (VIRTUAL REALITY)

Now, we will start gaming session 2. Please take this session seriously and follow the instructions carefully as they can have important consequences for our understanding of your game-playing experience.

OBJECTIVE/GOAL: Your task during this session is to ***play the game using Oculus Rift*** by taking the role of a counter terrorist.

- After 10 minutes, your session will be stopped by the researcher.
- Fill out the post-study questionnaire in the Qualtrics window based on your experience in this session.

APPENDIX F.

SUBJECT BACKGROUND QUESTIONNAIRE

1. What is your age? (18-24, 25-29, 30-34, 35-39 and, 40 or above)
2. What is your highest level of education? (less than high school, high school graduate or equivalent, associate degree or equivalent, bachelor’s degree, postgraduate degree)
3. Please estimate your total number of years of computer gaming experience. (Less than 1 year, 1 – 3 years, 3 – 6 years, 6 – 10 years, Over 10 years)
4. Approximately how many hours per week do you spend playing first-person shooter game(s)? (Never played it before, Less than 10 hours, 11-20 hours, 21-30 hours, More than 30 hours)
5. Please estimate the total number of years you have played Counterstrike. (Less than 1 year, 1 – 3 years, 3 – 6 years, 6 – 10 years, Over 10 years)

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VITA

Sri Chaitanya Sanaboina was born in Andhra Pradesh, India. In April 2014, he received his Bachelor's degree in Mechanical Engineering from Jawaharlal Nehru Technological University, India. He then joined Missouri University of Science and Technology (formerly University of Missouri – Rolla) in Spring 2015. He earned a Graduate Certificate in Enterprise Resource Planning in May 2016 and completed his Master's degree in Information Science and Technology in July 2016.