The Impact of Controller Naturalness on Spatial Presence, Gamer Enjoyment, and Perceived Realism in a Tennis Simulation Video Game

Abstract

The introduction and popularity of the Nintendo Wii home console has brought attention to the natural mapping motion capturing controller. Using a sample that identified sports as their most frequently played video games, a mental models approach was used to test the impact that perceived controller naturalness (traditional controller vs. natural mapping motion capturing controller) had on perceptions of spatial presence, realism, and enjoyment. The results showed that perceived video game realism is a predictor of spatial presence and enjoyment. Furthermore, the results supported predictions that controller naturalness would influence perceived video game realism of graphics and sound. Future research should investigate whether or not these controllers lead to greater presence and enjoyment in different genres of games (e.g., first-person shooters). In addition, future research should consider whether or not these controllers have the ability to prime violent mental models.

1 Introduction

The worldwide success and popularity of Nintendo’s fifth home console system, Wii, has revolutionized the video game industry and led a surge in demand for games that utilize motion capturing technology. The Wii’s primary selling point is its natural mapping motion capturing controller that can be used to simulate almost anything and has been very popular among otherwise non-traditional gamers (Brightman, 2008). In fact, by selling over 687,000 consoles in 2008, the Wii outsold the Xbox360 and Playstation 3 consoles combined (White, 2008). According to a Bloomberg report, Wii sales were up 37% in 2008, despite a 7% decrease in industry sales across the board (White).

Nonetheless, the Wii itself is only one example of this gaming revolution. Throughout the history of video games, efforts have been made to provide players with more natural means of interaction, sometimes through means of more natural controllers that use the natural mapping of body movements that simulate those typically used for a given event (e.g., playing golf). The concept of controller naturalness represents the overall intuitiveness a controller is perceived to have when interacting with a virtual environment. The first arcade

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games in the 1970s incorporated natural mapping controllers (steering wheels) to make games more realistic (Skalski, 2004). Currently, a common thread among music genre games is the unique realistic motion capturing controllers. Take Rock Band as an example: the game features guitars, microphones, and drum sets as controllers. Gamers interact with the system by using these instruments to play in a virtual band. However, it’s not just Rock Band and Guitar Hero that are utilizing these realistic natural mapping controllers; other games are as well, such as Dance Dance Revolution, Karaoke Revolution, and even nonmusic games like Mario Kart. In addition, there are a number of realistic natural mapping motion capturing controller systems being utilized outside of the entertainment realm. The U.S. military is one example where realistic natural mapping controllers are used to enhance the realism of the interaction between the user and the virtual environment. In a game entitled Virtual Battle Space 2, which is used for training, soldiers use controllers that look and feel like authentic weaponry.

Clearly, it is no longer appropriate for social researchers to just examine what games do to people; it is time we explore how people interact with games, and how controllers are influencing the overall experience. Using a realistic tennis simulation game, this study investigates the influence natural mapping motion capturing controllers are having on perceptions of spatial presence, perceived realism of video games’ graphics and sound, and overall enjoyment of game play.

2 Literature Review

Mapping can range from arbitrary (unrelated to virtual behavior) to natural (related to virtual behavior; Skalski, Tamborini, Shelton, Buncher, & Lindmark, 2011). Natural mapping is characterized by a system’s ability to map its controls to correspond to changes within a mediated environment, doing so in a manner that is natural and predictable (Skalski et al.; Steuer, 1992). In a study (Skalski et al., 2011) that compared realistic mapping controllers (e.g., steering wheel) to other nonrealistic mapping controllers (joystick, keyboard), it was clear that a controller that naturally replicated real behaviors (steering wheel) in the virtual environment led to increased levels of presence and enjoyment. Tamborini and Skalski (2006) argue that this effect is related to the gamer’s ability to access mental models of the behavior more quickly and accurately using these realistic natural mapping controllers. However, research surrounding the use of natural mapping motion capturing controllers is limited and has yet to explore the impact that controller naturalness may have on perceived levels of a game’s realism.

2.1 Natural Mapping Controllers and Mental Models

Mental models can be defined as cognitive representations of situations that may be found in a real or imagined world (Roskos-Ewoldsen, Roskos-Ewoldsen, & Dillman Carpentier, 2002). Mental models are formed through previous personal and social experiences and can represent both actual and hypothetical events. Because mental models are cognitive abstractions of real events, they contain motives for actions, directions about how to behave, appropriate emotions for an event, and even ideas regarding the physical properties of an event, action, or behavior. Thus, we can have mental models for people (e.g., athletes, coaches), events (e.g., the Super Bowl) and actions (e.g., playing a sport). In terms of video games, an individual’s mental models (e.g., for playing tennis) may help him or her make decisions such as where to go, when to swing, or which shot to take. All of the decisions made by an individual within the virtual environment are influenced in part by experiences in the real world and the mental models that have developed over time. In other words, our knowledge of the real world (including our knowledge of video game play, as we will discuss shortly) and our knowledge of real-world situations may be one set of mental models that we bring to a gaming situation.

Mental models may also be formed and reinforced through previous media experiences, or in the context of this research, an individual’s prior usage of video games. Video games offer a virtual reality where users form and rely on mental models to make decisions. For example, using realistic tangible natural mapping controllers, such
as a steering wheel for a car racing game such as Gran Turismo or a guitar for a music game such as Guitar Hero, minimizes the gap between the controller and the virtual on-screen action, providing gamers easy access to relevant real-life mental models (Skalski et al., 2011). A gamer’s expectations may be based on previous real-world experience, experience with the medium, or a combination of both. It should be articulated that an individual’s understanding of video games is part of their more general mental models, and experience with games in the past may allow a player to suspend or ignore “real-world” mental models in the virtual environment. For example, humans cannot fly in real life; however, they may suspend this belief in a virtual environment that allows them to fly, leading them to rely on mental models from previous game play experience(s).

As games strive to be more realistic, it has been the controllers that have limited their realism at times with their arbitrary input systems. As Poole (2000) points out, the control systems for video games have been the most “unreal” aspects of video games (e.g., push button “b” to jump), yet the majority of console gamers still interact with traditional button and joystick controllers that utilize a limited amount of natural mapping (Williams, 2002). Nevertheless, there is a certain value associated with controllers that employ a natural mapping approach.

Traditional controllers do very little to minimize the gap between the virtual world and the user’s ability to interact with the world in terms of learning or applying existing skills. In other words, button and joystick controllers that do not feature natural mapping force users to learn new ways of carrying out some behaviors they have already learned to do in the real world. The human motor control system relies on replication as a means of developing and perfecting a particular skill (Downs & Oliver, 2009). Video games offer a unique opportunity for humans to practice certain motor skills within a very low-risk environment. Games that allow real human behavior to be captured and implemented into the virtual world allow users to practice and test their motor skills while receiving feedback on the accuracy of the kinesthetic input. The dynamic motion created by the real-world user is reproduced by the user’s character or avatar, allowing it to become a virtual model of the user’s behavior. The interactive gap between the user and the virtual world can be minimized through the use of motion capturing technology but also through the activation of existing or previous experiences or mental models.

Model merging is a term used to describe the cognitive associations made by a user in an effort to connect real-world behaviors to the behaviors being used to interact with a particular game. Every video game features unique mechanics that a user must learn to manipulate in order to be successful. The ability to learn a particular game’s mechanics and more specifically a game’s controls can be influenced by the level of familiarity the user has with previous games or the control features. Motion capturing controllers allow for users to rely on real-world behavior to interact with the environment which in many cases allows them to rely on existing cognitive structures for an understanding of how to be successful. In the context of sports and more specifically tennis, users can rely on their previous experience with the sport, whether it be an experience playing or watching. For tennis, the ability to interact with the environment is made easier through the use of a motion capturing controller because it requires less cognitive effort and the game’s model can be more quickly merged with the individual’s existing mental models.

Greater levels of natural mapping have been shown to increase perceived levels of controller naturalness among gamers (Skalski et al., 2011). Tamborini and Skalski (2006) argue that natural mapping controllers lead to quicker mental processing and enhance the gamer’s ability to make accurate decisions within the virtual environment. The quicker mental processing attributed to natural mapping controllers can be explained by the user’s ability to rely on existing cognitive structures as opposed to having to learn a new and arbitrary control system for interacting with the environment (Boyan, 2009). The concept of a user’s matching his or her own models with the game’s models is supported by research surrounding traditional active learning techniques. Therefore, the ability to use existing mental models and specific behaviors creates a distinctive link between the virtual world and the real world.
Given that a controller with high levels of natural mapping should align most closely with previously formed mental models of real-world behavior (Tamborini & Skalski, 2006; Skalski et al., 2011), the following is expected:

**H1.** Players of a tennis game who use a natural mapping motion capturing controller will experience and report a higher level of controller naturalness than those who play the game using a traditional button and joystick controller.

Furthermore, because mental models for past real experiences, if available, will be called on in a game environment, using a controller that mimics body movement in real life may help the player feel, in a more meaningful way, as if he or she is actually acting out real events/behaviors rather than playing a video game.

### 2.2 Controller Naturalness and Spatial Presence

The sensation of controller naturalness may be related to the construct of spatial presence, or the feeling of physical immersion within a virtual environment. Media researchers describe presence as a feeling of being virtually immersed in the media (Heeter, 1992; Kim & Biocca; 1997; Lombard & Ditton, 1997; Nowak, Krcmar, & Farrar, 2008; Steuer, 1992; Tamborini & Skalski, 2006). The concept of spatial presence has revolved around immersion and whether or not the mediated experience has led to feelings of immersion within a particular virtual environment or game space (Tamborini & Skalski). The nature of natural mapping motion capturing controllers embodies the concept of spatial presence by transferring real-world movements and behaviors of gamers directly into the virtual environment. The more natural the controller is perceived to be by the gamer, the greater levels of perceived spatial presence. Therefore, controllers that rely on the use of real-world mental models and realistic behaviors should lead to increased levels of perceived spatial presence.

**H2.** Perceived controller naturalness will positively predict perceived spatial presence.

Skalski et al. (2011) suggests that controller naturalness may itself be a dimension of spatial presence. However, this study did not consider the relationship between spatial presence and perceived video game realism. Higher levels of perceived video game realism have been shown to positively influence feelings of spatial presence (Krcmar & Farrar, 2007). If controller naturalness predicts spatial presence in this study, it may also be positively correlated with perceived realism. Perceived video game realism is distinct from spatial presence and could help extrapolate the difference between controller naturalness and spatial presence (see Skalski et al., 2011).

### 2.3 Perceived Video Game Realism and Controller Naturalness

In the past, perceived realism has been shown to influence outcome variables such as the effectiveness of health messages (Andsager, Austin, & Pinkleton, 2001), as well as presence, involvement, arousal, and excitement (Ivory & Kalyanaraman, 2007). In addition, Potter (1988) argues that more realistic portrayals are positively linked with enhanced social learning. Yet, few researchers have examined perceived realism as an outcome of the input device or channel being used, or more specifically, the perceived naturalness of a controller.

Traditional definitions of media realism from television and film have revolved around the representation of objects and whether or not the user considers those objects as something they would see in the real world (e.g., Atkin, 1983). Dimensions of these definitions from television and film have been used to define video game realism in the past; however, they do not adequately capture the dynamic interactive nature of video games. For example, Shapiro, Pena-Herborn, and Hancock (2006) offer that the “ability to imagine what a setting, character, or conflict would be like if it happened is a key ability in realism judgments” (p. 324). A problem with this approach to video game realism is that it does not consider the gamer’s judgment of how well the setting, characters, and most importantly behaviors are simulated. On the other hand, Frasca (2003) provides an excellent distinction between realism in television and
film and realism in video games. He suggests that while both sets of media are representative or modeling an object, video games are also simulating a model. Frasca (2003) states, “simulation does not simply retain the generally audiovisual characteristics of the object but it also includes a model of its behaviors” (p. 223). The system must react to the inputs of the user according to the rules of the game, and these inputs come directly and exclusively from the system’s controller, the primary channel of communication between the gamer and the system.

Therefore, to address this higher level of realism that takes place beyond representation, a revised conceptual definition of perceived video game realism is provided based on an interpretation of the previous literature (Frasca, 2003; Krcmar & Farrar, 2007; Nowak et al., 2008; Malliet, 2006; Shapiro, Pena-Herborn, & Hancock, 2006). Due to the unique interactive nature of video games, coupled with their multiple feature designs, perceived video game realism is a judgment of how accurately a game and its features have simulated a concept according to the gamer’s expectations.

A gamer’s expectations may be shaped by familiarity with the game, the game genre being examined, the gamer’s skill level, and/or the average amount of time spent with video games. These attributes have been found to be significant in studies that have explored the concepts of realism and presence in video games (Krcmar & Farrar, 2007; Nowak et al., 2008; Skalski et al., 2011). In addition, a gamer’s expectations are also going to be influenced by his or her real-world mental models of the simulation(s) the game is re-creating. As we evaluate the game’s ability to simulate a concept, we also evaluate the channel with which we are creating the simulation. If our mental models tell us that we should be able to do something and the controller does not allow us to do it, or simulates the behavior poorly, our perception of the game’s realism will be consequently affected. However, if a controller allows us to manipulate the environment in a natural manner, our expectations of the simulation should be met, thus leading to higher levels of perceived realism. For example, consider the nature of sports simulators. These games attempt to feature sports in a realistic-to-life manner. The physics of the athletic moves, the replication of real-world arenas, even the camera angles used in the game attempt to replicate the sporting experience, and have become more realistic over time as graphics have improved and computer processing speeds have increased. However, the interaction between the user and the game in these sports simulators is quite arbitrary when a traditional controller is being used. These games revolve around physical movement and well-timed execution, yet the real-world behaviors have no association to the in-game simulation when non-natural mapping controllers are employed.

Considering that human motor control is an interactive process between the senses, it is posited that as a more natural controller activates existing mental models, it should also prime the user’s senses. The motion capturing controller activates the motor control system, which, in the case of video games, relies heavily on sight, sound, and touch in order to communicate with the virtual environment. The two most apparent sensory features of video games are their graphics and sound. As controllers become more natural, the ability to interact with the virtual environment should become easier, through the model matching process, which activates existing mental models (past events and behaviors) as references for input. If a more natural controller allows the gamer to meet the game’s challenges by using some of their real-world mental models, their interpretation of the virtual environment should be considered more realistic. Therefore, based on the importance of the controller in communicating with the virtual outputs (graphics and sound) of the game, the more natural the controller is perceived to be, the more realistic the game’s features will be perceived:

**H3.** Perceived controller naturalness will positively predict perceived realism of graphics and sound.

Following this logic, if a game is seen as unrealistic, then unrealistic elements of the game (graphics, sound, controls) should serve as barriers to immersion (Krcmar & Farrar, 2007). The perceived realism of a video game is dependent on how well a game and its features have simulated a particular concept, event, or behavior. Therefore, based on this reasoning the following is expected:
H4. Perceived realism of graphics and sound will positively predict perceptions of spatial presence.

2.4 Enjoyment and Controller Naturalness

Research on video game uses and gratifications (Sherry & Lucas, 2003) tells us that gamers play for a number of reasons (e.g., to be competitive with self and others, for a unique social interaction, for a virtual distraction). However, as a multibillion dollar industry, enjoyment is perhaps the primary gratification sought by the use of video games (Klimmt & Vorderer, 2003).

Csikszentmihalyi’s (1990) flow theory has been applied to game development to increase the overall enjoyment of games for players (Dickey, 2005). Flow theory in respect to video games is described as a gamer having complete focus on a task or challenge within a virtual environment (Dickey). In order for flow to exist, researchers argue that there must be a balance between the game’s challenges and the gamer’s abilities (Dickey). In essence, a gamer’s skills must almost meet the game’s challenges in order for the gamer to experience some level of enjoyment or entertainment (see Dickey for a review).

A key dimension of flow in terms of enjoyment is the ability to control the environment being interacted with (Sweetser & Wyeth, 2005). The introduction of natural mapping motion capturing controllers makes it more likely that mental models of real-life skills and behaviors can be called upon within the virtual world and as a result enhances the game’s flow. Therefore, as a controller becomes more natural, it should increase the gamer’s abilities and make it easier to interact with the environment, consequently making it easier to meet the game’s challenges (Sweetser & Wyeth), leading to a more enjoyable experience, thus:

H5. Perceived controller naturalness will positively predict a gamer’s enjoyment of the game.

Finally, Skalski et al. (2011) posited that spatial presence would predict enjoyment. This finding was not supported and the researchers suggested that it could be an indication that perceived controller naturalness is actually a factor of spatial presence. However, there is reason to believe this relationship does exist. First, theoretically it would make sense for spatial presence to predict enjoyment. Spatial presence deals with the user’s feeling of being physically immersed in the virtual environment. As discussed above, video games are simulators and therefore the goal of the video game, especially in realistic sports simulations, is to create the most realistic simulator possible. If the simulation is perceived to be real, the user is more likely to enjoy that experience regardless of winning or losing, or the level of difficulty. Based on this logic, the following is predicted:

H6. Spatial presence will positively predict the gamer’s enjoyment of the game.

3 Method

3.1 Design

This study utilized an experimental posttest-only design. All participants played either the Playstation 3 or Wii version of the real-life tennis simulation game entitled Top Spin 3. Participants (N = 195) were randomly assigned to one of two conditions: high controller naturalness (Wiimote and nunchuk; n = 92) or low controller naturalness (Playstation 3 controller; n = 103). Students enrolled in participating courses received research credits worth no more than 1% of their total grade.

3.2 Participants

Participants were recruited from introductory level communication courses at a large northeastern university. The nature of the study did not require participants to be avid gamers in order to take part, as they were given a one-on-one instructional tutorial before playing. The age range for the sample was 18–24 years (M = 19.45; SD = 1.24), and 117 (60%) of the participants were male.

3.3 Procedure

Participants were run one at a time, to control for interactions with other participants. Upon arriving at the lab, participants were asked to fill out an instrument that
tested their knowledge of tennis along with their perceived video game skill level. After completing the first section, participants were invited into the gaming area which consisted of two couches, a lounge chair, a coffee table, an entertainment stand, and a 42-inch HD LCD television. The atmosphere was very relaxed and research assistants were instructed to make participants feel welcome and at home while playing.

Research assistants were given 5 hr of formal training on how to play each version of the game and how to instruct others to play using each controller. It was vital that the participants had a clear understanding of the controllers being used and this was addressed through the in-depth tutorial provided by the research assistants. Each demonstration lasted for ~5 min or until the participants indicated that they felt comfortable playing the game. Following the tutorial, participants were given 15 min to practice using the controller during which the research assistant sat with them to answer any questions and provide tips on how to use the controller more effectively. A pilot study was conducted to determine how long participants needed to play the game in order to become familiar with it. Based on the results, 15 min was selected as an appropriate time for participants to learn the basic controls and be able to use them successfully.

Following their initial practice round, participants were asked to fill out a second instrument, which consisted of the following scales: demographics, average time spent with video games, familiarity with tennis video games, preferred video game genre, and video game skill level. Upon completing the second set of questions, participants were instructed to play the game for another 15-min session. During this round, the research assistant did not assist or interact with the participant unless there was a question. Following this second session, participants completed a final instrument, which consisted of the following scales: perceived controller naturalness, perceived video game realism, perceived spatial presence, and game enjoyment. Participants were then thanked for their time, and asked not to communicate with their peers about the study.

### 3.4 Materials and Stimulus

The stimulus utilized was Top Spin 3. Top Spin 3 is a tennis game that features realistic graphics, sounds, and controls which all contribute to a rich virtual environment. In Top Spin 3, real life tennis players are featured, along with real-world tennis courts.

The main materials used by participants in the study were either a Nintendo Wii game controller, known as the Wiimote, or a Playstation 3 controller, which is essentially a traditional joystick and button controller. Participants in the high controller naturalness condition used the Wiimote as if it were a tennis racket, using realistic swings to interact with the virtual environment. See Figures 1 and 2 for pictures of the controllers.
In order to ensure consistency across conditions, participants using either controller played as Roger Federer, and their opponent was James Blake. The venue was set as the U.S. Open in New York, and participants played six-game, one-set matches. Game difficulty was set to easy for both conditions to ensure that all participants had a similar experience in terms of opponent difficulty.

### 3.5 Measures

#### 3.5.1 Perceived Realism of Graphics

The scale consists of seven items measured on a 7-point scale (1 = strongly disagree, 7 = strongly agree). The reliability for the scale was \( \alpha = .89 \). Some of the items included were: “The graphics in this game accurately simulated the look of a real tennis game,” “The graphics make this game more realistic,” “The graphics were similar to tennis in real life,” “The graphics looked like something I would see in real life,” “The graphics looked more like cartoons than real videos (reversed item),” “The players in this game looked like real tennis players or what I would expect real tennis players to look like,” and “The tennis courts looked like real tennis courts or what I would expect real tennis courts to look like” (see Table 1 for full scale).

#### 3.5.2 Perceived Realism of Sound

The scale consists of seven items using the same 7-point scale as noted above. The reliability for the scale was \( \alpha = .94 \). Some of the items included were: “The sound in this game accurately simulated the sounds of a real tennis game or what I would expect sounds of a real tennis game to be,” “The sounds in this game made it more realistic,” “The sounds in this game accurately represented the sounds of a tennis game in real life or what I would expect a tennis game to sound like in real life,” “The game sounded like something I would hear in real life,” “The sound quality was very realistic,” “The sound effects (swinging of the racket, running across the court, ball hitting the net, etc.) were realistic,” “The fidelity (quality of reproduction) and accuracy of the commentator’s voice (tones, inflections, etc.) was realistic” (see Table 2 for full scale).

#### 3.5.3 Perceived Controller Naturalness

A portion of this scale was developed and used in Skalski et al.’s (2011) study. The scale consists of 12 items measured on a 7-point scale, which proved to be reliable (\( \alpha = .90 \)). Some of the items included are: “The game controls seemed natural,” “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,” and “I felt like the controller was an extension of my body” (see Table 3 for full scale).

#### 3.5.4 Perceived Spatial Presence

Items used were adapted from a study conducted by Skalski (2011) that also uses the Nintendo Wii as its stimulus console. The alpha reliability of the 13-item scale was \( \alpha = .89 \).

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**Table 1. Perceived Realism of Graphics**

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<tr>
<td>The graphics in this game accurately simulated the look of a real tennis game</td>
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<td>The graphics make this game more realistic</td>
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<tr>
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<td>The tennis courts looked like real tennis courts or what I would expect real tennis courts to look like</td>
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**Table 2. Perceived Realism of Sound**

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<td>The sound in this game accurately simulated the sounds of a real tennis game or what I would expect sounds of a real tennis game to be</td>
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<tr>
<td>The sounds in this game made it more realistic</td>
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Participants were asked to indicate their responses on a 7-point Likert scale; however, as Table 4 illustrates, each item has unique response anchor points such as “always to never” or “not well to very well.” One of the items in the scale asks, “To what extent did you experience a sense of ‘being there’ in the environment you saw/heard?” See Table 4 for full scale.

### 3.5.5 Game Enjoyment

Enjoyment was measured using six items on a 7-point scale, adapted from Skalski et al. (2011) and proved reliable, $\alpha = .95 \ (M = 4.17, SD = .72)$. The items are: “I liked this game,” “I would recommend this game to my friends,” “I wish I could have played this game longer,” “I would like to play this game again,” “This was a fun game,” and “I would like to purchase this game.”

### 3.5.6 Perceived Gamer Skill Level

Each participant was asked to evaluate his or her own skill level using a slightly modified version of the one used by Skalski et al. (2011). The reliability for this nine-item, 7-point scale was $\alpha = .94 \ (M = 3.16, SD = 1.35)$. Some of the items included were: “I am a good video game player,” “I am familiar with different video game systems,” and “I think about video game strategies” (see Table 5 for full scale).

### 3.5.7 Average Time Spent with Video Games

To analyze approximately how much time participants spend with video games, participants were asked
to rate approximately how many days a week and how many days a month they played video games (either on the computer, in the arcade, or console/handheld games such as XBOX, XBOX360, Playstation 2, Playstation 3, Nintendo GameCube or Wii, PSP, Gameboy Advance, Nintendo DS). The average participant in our sample played video games 1.68 days a week (SD = 2.11) or 4.71 days a month (SD = 1.34).

3.5.8 Preferred Game Genre. Ten items were used to analyze which game genres participants enjoyed the most. The 10 game genres that were included in these measures were taken from a compilation of genres listed on popular gaming websites, particularly IGN.com and gamespot.com. Participants were asked to indicate how often (1 = never and 7 = frequently) they played each genre. The most popularly played game genre was “sports” (M = 3.53; SD = 2.15).

3.5.9 Knowledge About the Sport of Tennis. It should be noted that in our selection of stimulus, the researcher made a general assumption that the globally played game of tennis is a sport that most people have at some point seen and/or played, and will have some elementary understanding of how the game develops and the game’s overall goal. However, to empirically identify each participant’s knowledge about the sport of tennis, participants were given a short 10-question multiple-choice quiz. Questions were scored as right or wrong. The total number of correct answers represented each participant’s score for this variable. The average score on the quiz was a 7.37 (SD = 1.98) and 67% of participants scored a 7 or higher (see Table 6), indicating that participants were, in fact, relatively familiar with the sport of tennis.

3.5.10 Familiarity with Tennis Video Games. Finally, participants were asked to indicate their familiarity with other tennis video games. A list of all known tennis video games was provided and participants placed a check mark next to any of the games they have played before. A score between 0 and 39 was entered for each participant to represent his or her familiarity with tennis video games. The average number of games played among the participants in our sample was 3 (SD = 2.28) with a range of 0 to 13.

4 Results

Hypothesis 1 predicted that the natural mapping tennis racket controller of the Wii would be perceived as more natural than a traditional Playstation button and joystick controller. This hypothesis was supported, t (193) = 5.71, p < .01. The Wii controller (M = 4.62, SD = 1.03) was perceived as more natural than the Playstation 3 button and joystick controller (M = 3.80, SD = .96).

The remaining hypotheses are tested using a standard multiple regression approach with a two-block design. The first block in each model contained variables known to be related to the dependent variables of interest and, therefore, were entered as covariates: sex, age, perceived video game skill level, days a month spent playing video games, tennis video game familiarity, and knowledge about the sport of tennis.

Hypothesis 2 predicted that perceived controller naturalness would positively predict perceived spatial presence. This hypothesis was supported by the data. After entering the covariates listed above, perceived controller naturalness was entered into the second block of the
regression to see if this variable would account for a significant portion of the variance explained. Block 1 did not account for a significant portion of the variance in spatial presence, $F(6, 186) = 1.17, p = .32$. However, adding perceived controller naturalness in Block 2 returns a significant model, adjusted $R^2 = .29$, $R^2_D = .28$, $F(7, 185) = 12.25, p < .01$. Perceived controller naturalness was the only significant predictor of spatial presence in the model, $b = .51, t(185) = 8.71, p < .01$. This finding implies that gamers experienced greater levels of spatial presence as their perceptions of the controller’s naturalness increased.

Hypothesis 3 predicted that perceived controller naturalness would predict perceived realism of the game’s graphics and sound and was supported by the data. This hypothesis was tested using two separate multiple regressions. In the first regression, perceived realism of the game’s graphics was entered as the dependent variable. In the second block of the regression, the perceived controller naturalness was entered. Block 1 was not a significant predictor of the perceived realism of the game’s graphics, $F(6, 188) = .32, p = .92$; however, entering perceived controller naturalness in Block 2 returned a significant model and supported the hypothesis, $R(7, 187) = 2.13, p < .05$. Perceived controller naturalness was the only significant predictor in the model, $\beta = .26, t(187) = 3.59, p < .01$.

In the second regression, perceived realism of the game’s sound was entered as the dependent variable. The regression was conducted the same as detailed above and again the model containing controller naturalness was found to be significant, $R(7, 187) = 2.91, p < .01$. Again perceived controller naturalness was the only significant predictor in the model, $\beta = .30, t(187) = 4.28, p < .01$. Participants perceived the game to be more realistic in terms of graphics and sound as their perceptions of the controller’s naturalness increased.

Hypothesis 4 predicted that perceived realism of graphics and sound would positively influence perceptions of spatial presence and was supported. To test this hypothesis, the perceived realism of graphics and the perceived realism of sound were entered together in the second block. Block 1 did not account for a significant portion of the variance in spatial presence; however, adding perceived realism of graphics and sound to the model in Block 2 explained a significant amount of the variance in

<table>
<thead>
<tr>
<th>Table 6. Knowledge of Tennis Quiz</th>
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<tr>
<td><strong>Items</strong></td>
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<tr>
<td>If you just served for the first time in a game and score, how would you announce the score?</td>
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<tr>
<td>Another term used for a score tied at 40-40 is________.</td>
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<tr>
<td>If you were serving and hit the net on your first serve, what would this be called?</td>
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<tr>
<td>If you are serving, and score a point without a return from your opponent, what is this called?</td>
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<tr>
<td>On a return, your shot hits the line and your opponent does not return the shot; who gets the point?</td>
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<tr>
<td>If you are serving and the ball hits the net and carries over to land in the service box, what is this called?</td>
</tr>
<tr>
<td>True or false, tennis is an Olympic sport.</td>
</tr>
<tr>
<td>What are the tennis courts at Wimbledon made out of?</td>
</tr>
<tr>
<td>Which of the following is not one of the four grand slam tournaments: US Open, Australian Open, Wimbledon, French Open, or the Rogers Cup?</td>
</tr>
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<td>In what state is the US Open held?</td>
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An interaction between spatial presence and controller naturalness was tested and found not significant, $\beta = -.32$, $t(184) = -90$, $p = .37$. These findings imply that as gamers became more immersed in the virtual environment, their enjoyment of the game increased.

5 Discussion

The goal of this study was to contribute to the limited body of research on perceptions of natural mapping motion capturing controllers and their impact on feelings of spatial presence, game realism, and enjoyment, particularly in the realm of sports simulation games. The prediction that the natural mapping motion capturing controller would be perceived as more natural when compared to a traditional button and joystick controller was clearly supported. The results showed that controller naturalness can be a predictor of perceived spatial presence. Some researchers have suggested that controller naturalness is a subfactor of presence (Skalski et al., 2011); however, the beta coefficient, $\beta = .51$, $t(185) = 8.71$, $p < .01$, obtained for controller naturalness on spatial presence would suggest that these two concepts are independent of one another when measured appropriately. For game designers, the relationship between naturalness and presence may mean that gamers are starting to make both a mental and physical association between the controller interface and the virtual environment.

In other words, more naturalistic controllers help to narrow the gap between the user’s existing real-world mental models and the game’s models. Therefore, game designers would do well to design games that can utilize controllers that are able to match real-world behaviors with the required game behaviors as closely as possible.

Controller naturalness also predicted game enjoyment. Using a mental models approach to natural mapping controllers, the ability for gamers to rely on already existing schema allows them to think less about how to play the game and more on how to be successful. In addition, the existing literature tells us that enjoyment is an outcome of overcoming challenges within the game (Vorderer, Hartmann, & Klimmt, 2003). Furthermore, controller naturalness also predicted perceptions of spatial presence and a significant overall model was obtained, $F(8, 184) = 6.63$, $p < .001$. The adjusted $R^2$ for the significant model was .19, and significant regression coefficients were obtained for perceived video game skill, $\beta = .25$, $t(184) = 2.35$, $p = .019$, perceived realism of graphics, $\beta = .29$, $t(184) = 4.02$, $p < .01$, and perceived realism of sound, $\beta = .22$, $t(184) = 2.96$, $p < .01$.

As expected, perceptions of the game’s most outstanding physical features significantly impacted the participant’s sense of being spatially present in the virtual environment as showcased by the results found. The more realistic the game was perceived to be, the greater levels of spatial presence were experienced. An interaction effect between perceived video game skill level and perceived realism of graphics and sound was tested and found not significant, skill $\times$ graphics, $\beta = .23$, $t(184) = .59$, $p = .55$; skill $\times$ sound, $\beta = -.15$, $t(184) = -.31$, $p = .76$.

Hypothesis 5, which predicted that the participant’s perceptions of controller naturalness would impact his or her overall enjoyment of the game, was supported. Gamer’s enjoyment was entered as the dependent variable. Block 1 was not found to account for a significant portion of the variance in gamer enjoyment; however, adding perceived controller naturalness in Block 2 yielded a highly significant model and accounted for a large portion of the variance in gamer enjoyment, adjusted $R^2 = .38$, $R^2 = .37$, $F(7, 187) = 18.13$, $p < .001$. Controller naturalness was found to be the only significant predictor of enjoyment in the model, $\beta = .62$, $t(187) = 10.77$, $p < .01$. The results suggest that the more natural the controller was perceived to be, the more enjoyable the gaming experience was.

Hypothesis 6 predicted that spatial presence would significantly predict game enjoyment. Again, the covariates were entered into Block 1 along with perceived controller naturalness. Spatial presence was entered in Block 2. Block 1 did account for a significant portion of the variance, $F(7, 185) = 17.40$, $p < .001$. However, entering spatial presence in the second block significantly improved the model, adjusted $R^2 = .44$, $R^2 = .40$, $F(8, 184) = 19.64$, $p < .01$. Perceived controller naturalness yielded a significant regression coefficient, $\beta = .49$, $t(184) = 6.86$, $p < .01$; spatial presence was also a significant predictor, $\beta = .30$, $t(184) = 4.65$, $p < .01$. An interaction between spatial presence and controller naturalness was tested and found not significant, presence $\times$ controller naturalness, $\beta = -.32$, $t(184) = -.31$, $p = .76$. These findings imply that as gamers became more immersed in the virtual environment, their enjoyment of the game increased.
graphic and sound realism. The importance of perception is key to this finding. Based on the logic that natural mapping controllers prime individuals’ mental models, we conclude that perceptions of realism are being influenced by the means by which the environment is manipulated, and the perceived naturalness of the controller. In other words, moving your arm like you are swinging a tennis racket is closer to a real-life mental model for playing tennis than pushing buttons; and this contributes to perceptions of realism.

In addition, perceptions of the game’s realism (graphics and sound) significantly predicted the participant’s sense of feeling spatially present in the virtual environment. The impact of this finding is significant as it suggests that realism perceptions are not solely based on just the game’s graphics and sound. The ability of the player to overcome challenges is the cornerstone of flow theory, and this finding supports the idea that a more natural controller not only increases the gamer’s abilities, but that their ability to control the game is connected to their perceptions of what is perceived as realistic in a gaming environment. Therefore, the process uncovered seems to be that as the controller becomes more natural, it makes the game seem more realistic. The enhanced realism and controller naturalness creates a seemingly more immersive environment for the user to become involved in. The ability of the user to quickly match their existing models to the game’s models is enhanced through the perception of naturalness and realism. The minimized gap between real-world behaviors and virtual environment becomes a mechanism for activating the user’s motor control system, therefore drawing the user closer into the mediated environment and ultimately making it easier to interact and be successful, which, as suggested by the results, leads to an overall more enjoyable gaming experience. Ultimately, these findings validate the mental models approach as an interesting and relevant means to understanding how people interact with the virtual environment, presumably due to this minimized gap between the game environment and the real one. Recall that mental models approach would argue that we have mental models for a variety of experiences. In this case, gamers presumably have a model for both real tennis and video game play. However, by minimizing the gap between the two, the mental models may become closer and closer, perhaps resulting in an eventual match. Theoretically, this would lend support to the notion that mental models are malleable and can be influenced by the environment. Practically, it suggests that the more vivid and similar to reality our mental model is, the more likely we are to enjoy a mediated experience that is intended to mirror an enjoyable real-life experience.

One of the questions raised by this study is whether or not the effect of controller naturalness on enjoyment is the same for both high and low skill level gamers. A post-hoc t-test compared high and low skill level gamers on their enjoyment of the game. The results of this test showed that there was no difference between high and low skill level gamers in terms of their enjoyment of the game, $t(193) = -0.067, p = .95$. High skill level gamers, $M = 4.16, SD = 1.59$, found the game to be just as enjoyable as low skill level gamers, $M = 4.18, SD = 1.48$.

On the other hand, a significant regression coefficient, $\beta = .25, t(184) = 2.35, p = .019$, was obtained from Hypothesis 4 showing a significant positive relationship between video game skill and feelings of spatial presence such that more experienced gamers had higher levels of spatial presence. A potential explanation for this finding comes from the literature on gamer skill and experience such that more experienced gamers are possibly less distracted by figuring out the game and its controls, and have greater cognitive ability to concentrate on the game at hand, thus leading to greater presence when playing (Bracken & Skalski, 2006). Bracken and Skalski offer the explanation that interactive game play allows users to determine a majority of the content they are exposed to, and depending on a gamer’s skill level and familiarity, the game play may be more or less realistic. Thus, players with lower skill levels may struggle to move through an environment or complete certain tasks, making it less likely to become immersed in the game. Another possible explanation for this outcome is that more experienced and more skilled gamers have stronger and more established mental models for video games, thus enabling them to feel closer to the virtual environment and experience greater levels of spatial presence.
The results of this study have some particular value to game designers as well. Given that perception of realism was greater for the Wii condition over the Playstation 3 condition, users’ perceptions of realism are not solely based on graphics. The theoretically causal link that suggests controller naturalness can influence perceptions of realism was supported with empirical evidence in this study and suggests that how we interact with the game can be just as important if not more important than how the game looks. The development of realism has been a focus for game designers who have utilized the advancements of computer processing speeds to enhance game graphics and sound. Yet, the controller is the primary mode of communication with the gaming console and users have developed an understanding of the types of things controllers can and cannot do. The introduction of motion capturing needs to be closely monitored by designers in an effort to determine where its usage is going to be perceived as most effective. The use of motion capturing controllers may not be appropriate for all games. In addition to this, the accuracy of the in-game kinetic modeling must be considered an important area of development given the opportunity for games to help users practice and perfect a countless number of real-world behaviors.

5.1 Limitations

As with all experiments, this study had its limitations. First, the experimental lab setting may not be as generalizable as research conducted in the field. Although our lab design was not perfect, it was set up to reflect a dormitory setting intended to re-create a more natural gaming experience for our participants. Some also might consider using a convenience sample of college students a limitation and although the sample may not be a complete representation of the population of video game players it is somewhat accurate. The majority of our participants had some familiarity with both video games (78% played video games at least once in the last month) and tennis video games (93.3% had played a tennis video game before). Also, the perceived skill level of each individual was controlled for in the regression analyses and the game play experience was held constant across participants within conditions by using the same difficulty settings, characters, and arenas. Future researchers could consider implementing a design that allows for the user skill level to be considered before interacting with the game to allow for an adjustment of difficulty level unique to each individual within the game.

An additional limitation was that the study utilized only one game and one play experience. It may be that there are important differences between tennis games and tennis controllers that differ from other types of games that utilize natural mapping. Thus, future research should seek to test if the same findings can be replicated across other games and across additional play situations.

A final limitation in this study may have been the slight difference of graphic quality between the two experimental conditions. In order to execute this experiment, two different game systems had to be used, which meant that no matter how close the games were, there were still going to be some differences due to the nature of the consoles themselves. The Playstation 3 has a much larger processor and therefore produces graphics of a higher nature. Upon visual inspection of the two conditions the graphics were noticeably better on the Playstation 3 console. However, this should not take away from the more general findings and the strong support for a positive relationship between perceived controller naturalness and perceived realism of graphics and sound.

5.2 Future Research

The context of this experiment revolved around the sport of tennis, which lends itself wonderfully to the world of natural mapping motion capturing controllers. However, before we had natural mapping motion capturing controllers, there were still tennis games. As more games, especially nonsports games, are being developed to use natural mapping motion capturing controllers, future research needs to examine which types of games or genres are most acceptable for this controller format. For decades game development focused on developing more realistic graphics, better
storylines, and more complex worlds, yet, the next generation of games must now consider how gamers will interact with the virtual world and whether or not natural mapping motion capturing controllers should be included in the design.

Future research must continue to examine whether or not natural mapping controllers have the ability to increase skill levels in real-life athletes. As virtual environments evolve into more realistic representations, researchers should pay close attention to how players are interacting with these environments. The learning experience is only beneficial if the controller acts and reacts in a predictable fashion. In the sports context, athletes can only improve their skills if a controller’s interface is perceived as natural. The current research tells us that the more natural a controller is perceived, the more likely the user is to experience greater levels of presence. The relationship between naturalness and presence must continue to be examined.

The social impact of these new natural mapping motion capturing controllers has potential for both positive and negative outcomes. There is no question that natural mapping motion capturing controllers are making games more realistic; however, the question being raised by this increase in realism is whether or not these higher levels of realism will lead to higher levels of aggression or other negative outcomes. The swinging of a tennis racket repeatedly in your living room may lead to a stronger forehand in real life or a potentially sore elbow. On the other hand, throwing punches at the screen in your living room may translate to throwing better punches on the school ground, a serious and potentially negative side-effect of the natural mapping motion capturing controller.

These motion capturing controllers allow players to practice real-life skills in some cases, and have great potential to teach new skills. There have been reports of surgeons warming up before surgery by using video game simulations (JAMA and Archives Journals, 2007), and for decades the armed forces have been using video games to train their soldiers. However, they also open the door for potentially dangerous situations where there are gamers learning how to re-create and embody some very dangerous and antisocial behaviors. These issues have long surrounded the gaming world; however, the introduction of motion capturing natural mapping controllers changes the landscape drastically. Future research must now consider the impact motion capturing natural mapping controllers may have on aggressive mental models.

References


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