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Abstract

This investigation examines how video game interactivity can affect presence and game enjoyment. Interactivity in the form of natural mapping has been advocated as a possible contributor to presence experiences, yet few studies to date have investigated this potential. The present work formulates a preliminary typology of natural mapping and addresses how several types of mapping impact the experience of a video game, with the expectation that more natural mapping leads to increased spatial presence affecting enjoyment. Two studies were conducted. In the first study, 48 participants played a golfing video game using one of two controller types (Nintendo Wiimote or gamepad). In the second, 78 participants played a driving video game using an even more natural controller (steering wheel) or one of three other controller types. Participants then completed measures of perceived naturalness, presence, and enjoyment. Results of both studies were generally consistent with expectations.

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Introduction

The popularity of video game entertainment has soared in recent years. In 2008, the game industry reaped record profits of $21.33 billion in the USA, up 19 percent from the previous year (Sinclair, 2009). One reason for the ascendancy of video games is technological advancements. Game industry growth has traditionally been fueled in part by technical innovation (Williams, 2002), and many exciting developments have happened in the newest generation of gaming consoles, including High Definition (HD) graphics and new game playing controllers, the primary focus of this investigation.

Game controllers have progressed considerably over time, from the single-button joysticks of the late 1970s to the multi-button and stick controllers of today. These advanced control devices allow players to perform a range of actions conducive to the experience of *presence* (Tamborini and Skalski, 2006), 'the perceptual illusion of non-mediation' (Lombard and Ditton, 1997). Although research has identified technological advancement in games as a determinant of play outcomes (Ivory and Kalyanaraman, 2007), few studies to date have specifically explored the effect of game controllers on presence and resultant game enjoyment, even though interfaces have received much attention from the industry in recent years. Nintendo made motion controllers the focus of its Wii console, and Microsoft and Sony just announced that they will be releasing similar technologies (Paul, 2009). These developments point to the potential importance of *natural mapping*, or 'the ability of a system to map its controls to changes in the mediated environment in a natural and predictable manner' (Steuer, 1992: 47).

Natural mapping has been suggested as a possible determinant of video game-induced presence (Tamborini et al., 2004) due to its ability to complete 'mental models' people have for real-world activities (Tamborini and Skalski, 2006). However, it has received little empirical attention in the literature on presence and video games. The present study attempts to: (a) specify dimensions of natural mapping, and (b) empirically test the notion that natural mapping affects presence and other outcomes of game exposure. This is achieved by manipulating the control devices used to play video games. It is expected that game controllers higher in natural mapping will lead to more perceived controller naturalness, which should positively affect spatial presence and resultant game enjoyment. Note that natural mapping and presence are not presented as the sole determinants of video game enjoyment. Rather, they are advanced as potential contributors (among many) to enjoyment and empirically examined with the expectation that natural mapping and presence contribute unique variance to player enjoyment.

Natural mapping and video games

The term 'natural' and related concepts like 'nature' and 'naturalness' have been used differently in various domains of inquiry (e.g. discussions of 'nature' versus 'nurture'). In this investigation, and consistent with work on the concept of presence, 'natural' will refer to the extent to which users of interactive technology perceive the interactivity to be predictable, logical, or in line with expectations. 'Naturalness' is therefore conceptualized as a psychological state dependent on both technology and individual differences. This leaves open the possibility that some users may be conditioned through repeated use over time to find certain interfaces highly natural, like keyboards and gamepads. But there should still be variation in perceived naturalness depending on the extent to which an interface is 'mapped' to real-life or in-game actions, the focus of this investigation.

Natural mapping in the context of video games is typically thought of as how closely actions represented in a game match the actions used to bring about that change in a real environment (Tamborini and Bowman, 2010). Efforts to provide video game players with more 'natural' modes of interaction have taken place throughout the history of the medium. Arcade games, for example, have traditionally included realistic controllers corresponding to real-life modes of vehicle operation, such as handlebars, wheels, and flight sticks. In spite of this, highly natural game controllers that mirror real-life or on-screen modes of interaction have been confined almost exclusively to arcade gaming. The vast majority of console players, representing the largest segment of the industry (Williams, 2002), have interacted with games through joystick or gamepad controllers. Simple, everyday actions like walking and jumping are controlled not through real movements but by pressing buttons, pushing sticks, and performing other minor, unrealistic actions that are not strongly connected to real-life actions. This restricts the physical involvement of game players and has historically diminished the potential of home gaming experiences to induce presence.

Several recent developments suggest that cybernetic realism in gaming is now here to stay. The most prominent of these developments was the November 2006 release of the hit Nintendo Wii console, which features an innovative, wand-like controller (the 'Wiimote') that responds to player hand and arm movements. To compete with the Wii, Microsoft and Sony (Nintendo's primary competitors) recently announced similar, naturally mapped control devices to be released for the respective Xbox 360 and PS3 consoles (Paul, 2009). These advancements point to the desirability (and profitability) of mapping in the experience of electronic games, but what, exactly, *is* mapping?

Mapping and mental models

In simple terms, *mapping* refers to the manner in which the actions performed by users of interactive media are connected to corresponding changes in the mediated environment (Steuer, 1992). It can range from arbitrary (unrelated to the function performed) to natural (related to the function performed). An example of a device with *arbitrary* mapping would be a QWERTY keyboard used to control a video game through randomly assigned keys. If 'G' made a character move up, 'T' made the character move down, etc., these controls would be unrelated to the actions being performed. An example of a high *natural* mapping device would be a bat controller used to hit in a baseball video game, given that swinging the bat would correspond to nearly the same action in the game or real life. The extent to which mapping exists is expected to directly affect a media user's perception of controller naturalness.

The value of having more mapped controllers might best be understood as a function of *mental models*, or cognitive representations of situations in real or imagined worlds, along with the entities and events within those situations and interrelationships between them (Roskos-Ewoldsen et al., 2009). Mental models form to represent many different types of actual situations or possible worlds (vanDijk, 1998), including real and virtual objects, and they may be inscribed though repeated media use (Tamborini and Bowman, 2010). In other words, mental models can develop through direct or mediated experience. Some have argued that our ability to understand actions and events is determined by the mental models we construct (Halford, 1993; Wyer and Radvansky, 1999). Applied to video games, Tamborini and Skalski (2006) argue that more naturally mapped gaming controllers should allow players to quickly access mental models of real-world behavior, if they exist for the player, thereby providing more accurate and available information about how to interact with the game. This is expected to facilitate *spatial presence*, the sense of being physically located in a virtual environment (Wirth et al., 2007), since players focus less on the controls (to the extent that they perceive them to be natural) and more on the game itself. In addition, Biocca (1992) argues that human perceptual and motor systems are optimized for real-life interaction; therefore, adapting virtual controls to movements of the human body should bring about heightened levels of presence.

A typology of natural mapping

Despite the budding popularity and seeming importance of natural mapping in interactive entertainment, not much attention has been directed toward explicating this concept. Uncovering the dimensions of mapping and empirically testing them can help predict the effectiveness of interactive control devices such as those used to play electronic games as well as strengthening our understanding of how and why they work. The present research formulates and discusses four possible types of mapping and the likely relationship of each to mental models and gaming experiences. Note that these mapping types are not orthogonal and may overlap with one another. They are also not the only types of mapping but rather fall along the continuum from completely arbitrary to completely natural. The four types (in order of naturalness) are: (1) directional natural mapping, (2) kinesic natural mapping, (3) incomplete tangible natural mapping, and (4) realistic tangible natural mapping.

Directional natural mapping

The most basic manner in which controllers can be more naturally mapped is by producing a correspondence between the directions used to interact via a control device and the results in the world or on a screen. As Norman (1986, 1988) points out in his seminal work on the topic, natural mapping takes advantage of physical analogies and cultural standards, leading to 'immediate' understanding. Norman (1988) provides an example of directional mapping by discussing stoves with four burners arranged in the traditional 2×2 square. Most stove controllers are laid out in a straight line, making it difficult to tell which controller affects which burner; more naturally mapped stove controllers would also be set up in 2×2 rectangular form. Even though there may be a disconnect between the actions used to control and the specific actions that happen in response, as in the case of using a joystick to make a game character walk, simply having 'up' on the stick lead to 'forward' movement, 'left' lead to 'left,' etc. represents a basic form of natural mapping. Without these natural directions, confusion and frustration may result, since unnatural actions work counter to existing mental models for behavior.

Kinesic natural mapping

A second type of natural mapping involves body movements that correspond to real-life actions *without* having a realistic and tangible controller. This type of mapping is perhaps best exemplified currently by video games played using the Sony EyeToy, such as *Air Guitar*. In this mini-game, the image of the player is captured by the EyeToy camera and placed on screen in front of a virtual guitar, which players must 'strum' along with using guitar-like motions. Microsoft just announced a similar motion control camera technology called Kinect for the Xbox 360. As Biocca (1997) suggests, close mapping of actual body movements to mediated body movements strongly influences media exposure outcomes. The extremely close mapping of a kinesic controller should call up mental models for real-life behavior and be perceived as fairly natural. However, kinesically mapped interfaces are missing the tangible stimulation of being in contact with a real-life object, e.g. holding a guitar, which should reduce naturalness to some extent by not completing a user's mental model for the behavior as easily as a realistic and tangible controller would (e.g. a held guitar control device, such as the one used in the popular *Guitar Hero* video games).

Incomplete tangible natural mapping

A third type of natural mapping involves giving players something that partially simulates the 'feel' of an object on the screen or in the game environment. Incomplete tangible mapping is the main function of the Nintendo Wii controller, since players grasp it similarly to how they would grasp real objects in the game world (e.g. a tennis racket or baseball bat). This should help complete the mental model for behavior more easily than simply performing realistic motions (as in kinesic natural mapping), although in the case of incomplete tangible natural mapping, the tangibility is limited. In the popular *Wii Sports* bowling mini-game, for example, players hold the Wiimote in a similar manner to how they would hold a bowling ball, but it does not have the round shape or weight of a real bowling ball, making it incomplete.

Realistic tangible natural mapping

The final type of natural mapping discussed in this paper adds a realistic, tangible element to provide the highest level of natural mapping relative to the other three. Many current arcade video games incorporate this highly realistic type of mapping in the form of driving wheel, handlebar, or gun controller. Realistic and tangible controllers such as steering wheels for driving games should allow users to most easily access mental models for the behaviors they are performing, allowing them to quickly close the gap between the disconnected controller and the actions that occur on the screen. The increased accessibility of these mental models is expected to enhance spatial presence and potentially even strengthen existing mental models for behavior over time, given the high similarity between the game actions and real actions (Tamborini and Bowman, 2010).

The foregoing description of the main types of natural mapping is not intended to be exhaustive, but rather to highlight a way of expanding current understandings of mapping for use and refinement in the future. It also suggests directions for research on mapping; the first study compares a standard game controller to an interface with incomplete tangible natural mapping.

Study one: rationale and hypotheses

A controller with incomplete tangible natural mapping should cause players to experience more perceived controller naturalness than an interface with directional natural mapping, given that the tangible controller more easily completes pre-existing mental models of behavior for players (Tamborini and Skalski, 2006). In this initial investigation, the decision was made to compare popular, commercially available types of game controllers (Nintendo Wiimote and Sony PS2 gamepad) with the hope of creating a range of perceived naturalness scores. It may be that common gamepad controllers are perceived as natural by gamers. However, we believe that tangibly mapped controllers should still be perceived as more natural given the closeness with which they replicate real-world action. The following was therefore expected:

> H1a: Players of a game with an incomplete tangible mapped controller will experience a higher level of perceived controller naturalness than those who the play the game using a directionally mapped interface.

Perceived controller naturalness, which represents a continuum of responses to natural mapping, should relate positively to spatial presence, as suggested by Tamborini and Skalski (2006). The reasoning behind this claim is that natural interfaces require less thinking about controlling the game and therefore allow players to more effortlessly feel ‘in’ the game. In addition, controls with more natural mapping help ‘complete’ being in a mediated space and should contribute to spatial presence through perceived controller naturalness, as suggested in the following hypothesis:

> H2: Perceived controller naturalness positively predicts spatial presence.

Media entertainment has received considerable attention from scholars of late (Vorderer and Hartmann, 2009), and being present in the ‘space’ or environment of a video game is expected to relate directly to game enjoyment (Tamborini and Bowman, 2010). Some scholars have made explicit connections between media entertainment theories and presence, including linking media interactivity to spatial presence to resultant enjoyment (Klimmt and Vorderer, 2003). Games that create a sense of spatial presence should cause players to feel more ‘there’ in exciting locations (e.g. a battlefield, race car track, golf course, etc.), leading them to enjoy their experience more:

> H3: Spatial presence positively predicts video game enjoyment.

Finally, given the importance of enjoyment to the game industry, questions remain about other variables that may impact this outcome. What, exactly, causes people to enjoy video games? Uncovering these predictors can increase our understanding of why people play games. We realize that a complete enumeration of factors affecting enjoyment is beyond the scope of this or any single empirical study, but this investigation at least explores a number of possibilities:

RQ1: What other variables predict video game enjoyment?

Study one: methods

Overview

A total of 48 participants played a golf video game as part of a lab experiment that manipulated *type of controller*. Players were randomly assigned to play the game for 10 minutes using either a (1) gamepad or (2) Wiimote to vary the level of natural mapping experienced. Following this, they completed measures of perceived controller naturalness (included as a manipulation check), spatial presence, enjoyment, prior game use, skill, and demographic characteristics.

Participants

Participants were undergraduate communication students at a medium-sized Midwestern university who received course credit for their participation. The age range was 19 to 24 years ($M = 21.46$; $SD = 1.02$), and 25 (52%) of the 48 players were male. In each condition, players were informed they would be taking part in a study on people's reactions to video games.

Stimulus and controllers

All participants played the video game *Tiger Woods PGA Tour 07.* This entry was released simultaneously on both the Nintendo Wii and Sony PS2, with the only major difference being manner of control. In the tangible natural mapping condition, participants played the game on the Nintendo Wii and controlled their avatar's golf club by swinging the Wiimote in natural fashion, as if they were holding a real golf club. In the directional natural mapping condition participants played the game on the Sony PS2 and controlled their avatar's golf club using a standard Sony Playstation gamepad, which involved pulling and pushing an analog stick with their thumb. Since the Wii version was designed to be played in natural fashion, participants were required to stand up while playing this version, whereas participants in the PS2 condition sat down.

Procedures

Upon arriving at the research laboratory, participants were asked to fill out a consent form. They were then escorted into a room containing a 52-inch screen television and a comfortable couch, which sat 4.77 feet from the screen. They were asked to sit in the middle of the couch (in the gamepad condition) or stand in front of the couch (in the Wiimote condition). Once in place, the experimenter briefly explained how to play and control the game, after which the game was started and the participant was left to play alone (through as many holes as they could) for 10 minutes. After the allotted time, the experimenter returned and administered the questionnaire. Once finished, the participant was debriefed and dismissed. The experimenter wrote down the player's score for each hole. No differences were observed in performance between the two conditions. The entire process took 30–40 minutes.

Measures

Perceived controller naturalness. The extent to which participants perceived their game controller to be natural was measured using six items created for this study. The perceived controller naturalness measure included items such as 'The game controls seemed natural' and '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.' Measures were made on a 7-point scale (ranging from 'strongly disagree' to 'strongly agree') and summed to create an index of perceived controller naturalness ($\alpha = 0.80$).

Spatial presence. The degree to which players felt located in the game environment was measured using the Spatial Presence subscale of the Temple Presence Inventory (TPI) (Lombard and Ditton, 2000). Lombard and Ditton's work shows that cross-media measurement of spatial presence experiences is reliable and valid. The subscale had an acceptable level of reliability in the present study. Spatial Presence ($\alpha = 0.76$) included seven questions, such as 'How much did it seem as if the objects and people you saw/heard had come to the place you were?' and 'To what extent did you experience a sense of 'being there' inside the environment?' Measures were made on 7-point scales, with lower scores indicating absence or disagreement.

Enjoyment. Enjoyment of the gaming experience was measured by eight items, using a scale ranging from '1' (strongly disagree) to '7' (strongly agree). Responses to items such as 'This was a fun game' and 'I would like to play this game again' were summed to create an index of enjoyment ($\alpha = 0.96$).

Prior game use. Several measures of prior game use were included in this study. First, participants were asked to estimate the amount of time (in hours) they spend playing video games during (a) an average day and (b) an average weekday. These items were summed to create a composite measure of video game use frequency. Second, they were asked to indicate how often they play (a) sports games in general, (b) the Nintendo Wii, and (c) *Tiger Woods Golf* games on a 7-point scale, with '1' indicating 'not at all' and '7' indicating 'very often.'

Skill level. Using the Game Playing Skill (GaPS) scale created by Bracken and Skalski (2006), participants responded from '1' (strongly disagree) to '7' (strongly agree) to eight statements designed to assess skill level ($\alpha = 0.97$). The items included: 'I am a good video game player,' and 'I often win when playing video games against other people.'

Study one: results

A *t*-test was used to test H1, and the remaining hypotheses were tested using multiple regression. A path model was also advanced that combined key predictions.

Controller type and perceived controller naturalness

Hypothesis 1a, which predicted that an incomplete tangible mapped controller would be perceived as more natural than a controller with simple directional mapping, was supported. An independent samples *t*-test performed on perceived controller naturalness as a function of controller type was significant, $t(46) = -5.05$, $p < 0.01$. The Wiimote condition was perceived as significantly more natural ($M = 5.32$, $SD = 0.83$) than the gamepad condition ($M = 3.99$, $SD = 0.98$).

Perceived controller naturalness and spatial presence

Hypothesis 2, which maintained that perceived controller naturalness predicts spatial presence, was also supported. This hypothesis was tested by regressing sex, age, skill level, game play frequency, prior sports game use, prior Nintendo Wii use, prior use of *Tiger Woods Golf* games, and perceived controller naturalness on spatial presence, in two blocks. The first block contained all variables except perceived controller naturalness, which was added in the second block to see if it would account for a significant portion of the variance on top of the other variables in the equation. Block 1 did not account for a significant portion of the variance in spatial presence, $R^2 = 0.09$, $F(7, 40) = 0.581$, n.s.

In the second step, perceived controller naturalness was added to the model. This block significantly increased variance accounted for, $R^2\Delta = 0.11$, $F(1, 39) = 5.19$, $p < 0.05$. The regression coefficient for perceived controller naturalness was significant ($\beta = 0.35$, $t(39) = 4.91$, $p < 0.05$). The unique role of perceived controller naturalness in predicting spatial presence supports Hypothesis 2.

Spatial presence and other predictors of game enjoyment

Hypothesis 3, which stated that spatial presence predicts enjoyment, was not supported in the regression results. This hypothesis was tested by regressing the variables used in the prior hypothesis test and spatial presence on game enjoyment, in two blocks. The first block contained all variables except spatial presence, which was added in Block 2 to see if it would account for a significant portion of the variance on top of the other variables in the equation. Block 1 accounted for a significant portion of the variance in spatial presence, $R^2 = 0.63$, $F(8, 39) = 8.29$, $p < 0.01$. The individual regression coefficients for perceived controller naturalness ($\beta = 0.36$, $t(39) = 3.50$, $p < 0.01$), gender (maleness) ($\beta = 0.59$, $t(39) = 3.84$, $p < 0.01$) and prior sports game use ($\beta = 0.64$, $t(39) = 3.29$, $p < 0.01$) were significant. In Block 2, spatial presence was added to the model. This block did not significantly increase variance accounted for, $R^2\Delta = 0.03$, $F(1, 38) = 3.49$, $p < 0.10$, contrary to expectations.

Research Question 1 inquired about predictors of game enjoyment. Block 2, with all study variables, accounted for a significant portion of the variance in enjoyment, R^2 = 0.66, $F(9, 38) = 8.22$, $p < 0.01$. Significant regression coefficients included perceived controller naturalness ($\beta = 0.40$, $t(38) = 3.50$, $p < 0.01$), gender ($\beta = 0.59$, $t(38) = 3.84$, $p < 0.01$), and prior sports game use ($\beta = 0.64$, $t(38) = 3.29$, $p < 0.01$). Predictors that approached significance included age ($\beta = 0.21$, $t(38) = 1.99$, $p = 0.054$), skill ($\beta = 0.30$, $t(38) = 1.83$, $p = 0.08$) and spatial presence ($\beta = 0.19$, $t(38) = 1.87$, $p = 0.07$).

An alternative view: path analysis results

To gain a better perspective on these results, path analysis was performed on the model shown in Figure 1. This model included a direct path from perceived naturalness to enjoyment (in light of the regression results) along with the hypothesized relationships. It was tested using the least squares method, which involves estimating the sizes of the model parameters and testing the overall model fit. Parameter size was estimated by regressing each endogenous variable onto its causal antecedent, and model fit was tested by comparing estimated parameter sizes to the reproduced correlations (see Hunter and Gerbing, 1982, for a complete description of this analysis procedure). In short, a model that is consistent with the data is one which (a) has substantial path coefficients, (b) has differences between parameter estimates and reproduced correlations (errors) that are no greater than what would be expected through sampling error, and (c) passes a chi-square test of overall model fit.

Results for the model are shown in Figure 2. All but one of the paths was ample and significant. Controller type influenced perceived naturalness, with a path coefficient of 0.67, $P(0.47 < \rho < 0.87) = 0.95$. Perceived naturalness, in turn, increased both spatial presence, with a path coefficient = 0.44, $P(0.13 < \rho < 0.75) = 0.95$), and enjoyment, with a path coefficient of 0.46, $P(0.13 < \rho < 0.79) = 0.95$). Contrary to expectations but consistent with the regression results, spatial presence did not predict enjoyment, with a path coefficient of 0.05, $P(–0.34 < \rho < 0.44) = 0.95$).

The differences between predicted and obtained correlations for all unconstrained bivariate relationships were examined, and none were significantly different than what would be expected through sampling error. The model also passed the overall fit test, χ^2 (2) = 0.70, $p = 0.71$.

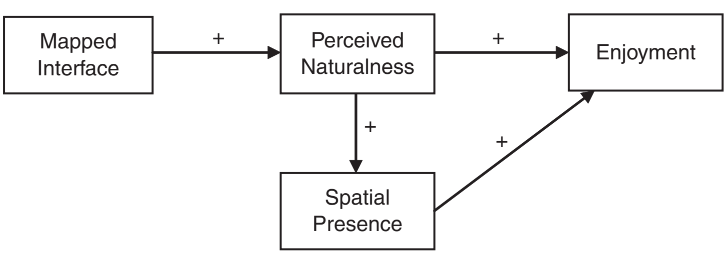

Figure 1. Model of expected relationships
Note. Path signs show model predictions.

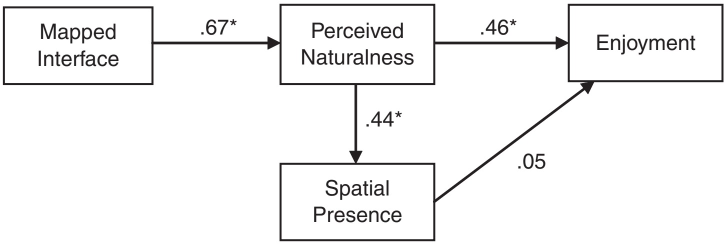

Figure 2. Results for Study One
$* = p < .05$
χ^2 (2) = .70, $p = .706$

Study one: discussion

Although the results of this study were generally consistent with expectations, the failure of spatial presence to impact enjoyment prompted the decision to include a second study intended to create even more spatial presence, primarily through the addition of a realistic tangible naturally mapped interface. In line with the typology presented earlier, realistic tangible natural mapping (such as a driving wheel) should be perceived as more natural than incomplete tangible mapping (such as that provided by the Wiimote) because it even more quickly and accurately completes the mental model for the real-world behavior. To test this expectation and maximize the potential for spatial presence, Study two added realistic tangible natural mapping with the following initial prediction (all other hypotheses were the same as in Study one):

H1b: Players of a game with a realistic tangible naturally mapped controller will experience a higher level of perceived controller naturalness than those who the play the game using other control devices.

The second study also varied the game genre by using a driving game instead of a golf game. This allowed for a test of the robustness of the mapping effect, since predictions were consistent in both studies, as well as providing a conceptual replication (Hunter and Schmidt, 2004).

Study two: methods

Overview

A total of 78 participants played a driving video game. The manipulated independent variable was, again, *type of controller*. Players were randomly assigned to play the game for 10 minutes using either a (1) keyboard, (2) joystick, (3) gamepad, or (4) steering wheel (most mapped). Following their gaming session, they completed the same measures as in Study one except for changes mentioned below.

Participants

Participants were from the same university and courses. The age range was 18 to 25 years (M = 21.08, SD = 1.39), and 45 (58%) players were male. In each condition, players were informed they would be taking part in a study on people's reactions to video games.

Stimulus and controllers

All participants played the PC version of the video game *Need for Speed Underground 2*. In this popular auto racing game players race through city streets against computer controlled opponents. The object of the game is to finish races in the fastest times. For this study, the game was set up so that players could not finish the race, which was done to reduce the likelihood that their success/failure would affect their responses.

Four different controllers were used in this study, and all but one (the gamepad, explained last) were mounted to a two-foot wide table in front of the seat from which the game was played. In the keyboard condition, players interacted with the game using a Logitech wireless keyboard and controlled their car using the arrow keys, with the left and right keys being used to steer left and right, the up key being used to accelerate, and the down key being used to brake. In the joystick condition, a Logitech Attack 3 joystick was the mode of interaction. Players controlled the game in the same manner as in the keyboard condition, only they moved the stick in the four directions as opposed to pressing buttons. In the steering wheel condition, a Logitech Momo Racing wheel was the mode of interaction. This highly rated interface (e.g. Day, 2005) simulates a real race car wheel that turns to move left and right and includes an accelerator and brake pedal for speeding up and slowing down. Finally, a Sony gamepad was included as a 'control condition' to match how most users play video games today and be consistent with Study one. Since console game players hold this type of controller without mounting it, this condition did not include the table.

Procedures

Upon arriving at the research laboratory, participants were asked to fill out a consent form. They were then escorted to the same room and TV as in Study one. They were asked to sit in the middle of the couch in front of the table upon which the controller sat (in all except the gamepad conditions). The remaining procedures were consistent with Study one. While the participant filled out the questionnaire at the end of game play, the experimenter wrote down what place the participant was in (first through fourth) to test for differences in player performance as a function of game controller. No trend of apparent differences in participants' performance was observed between conditions.

Measures

Methods used in the first study were replicated in the second study to measure *perceived controller naturalness* (α = 0.77), *enjoyment,* (α = 0.96), and s*kill level* (α = 0.97). *Prior game use* was measured first with the same frequency measure used in Study one. In addition, participants were asked to indicate how often they play (a) driving games in general, (b) the driving game used in the study, and (c) driving games with a wheel controller on a 7-point scale, with '1' indicating 'not at all' and '7' indicating 'very often.' *Spatial presence* was measured here using the Spatial Presence subscale of the ITC-Sense of Presence Inventory (ITC-SOPI: Lessiter et al., 2000) in place of the TPI measure in Study one. The measure was thought to provide an alternative, potentially more reliable assessment of spatial presence. This cross-media measure of spatial presence experiences (adapted to video games in the present study) includes 19 items, such as 'I felt I was visiting the places in the video game environment,' and has been shown to be reliable and valid in work by Lessiter et al. The subscale used in this investigation had an acceptable level of reliability ($\alpha = 0.93$). Each item was assessed using a 5-point scale ranging from 'strongly disagree' to 'strongly agree.'

Study two: results

ANOVA was used to test H1b; otherwise, all tests were the same as in Study one.

Controller type and perceived controller naturalness

Hypothesis 1b, which predicted that a driving wheel controller would be perceived as more natural than keyboard, joystick, or gamepad controllers, was supported. Univariate analysis of variance performed on perceived controller naturalness as a function of controller type was significant, $F(3,74) = 4.98$, $p < 0.01$, $eta = 0.17$. Subsequent LSD analyses revealed that the effect was induced by the driving wheel condition, as expected. The driving wheel condition was perceived as significantly more natural ($M = 4.74$, $SD = 1.18$) than the keyboard ($M = 3.67$, $SD = 1.34$), joystick ($M = 3.25$, $SD = 1.32$), and gamepad ($M = 3.78$, $SD = 1.22$) conditions, which were not significantly different from one another.

Perceived controller naturalness and spatial presence

Hypothesis 2, which maintained that perceived controller naturalness predicts spatial presence, was also supported. This hypothesis was tested by regressing sex, age, skill level, game use frequency, prior driving game use, prior steering wheel game use, prior use of *Need for Speed* games, and perceived controller naturalness on spatial presence, in two blocks. The first block contained all variables except perceived controller naturalness, which was added in the second block to see if it would account for a significant portion of the variance on top of the other variables in the equation. Block 1 accounted for a significant portion of the variance in spatial presence, $R^2 = 0.27$, $F(7, 69) = 3.45$, $p < 0.01$. The individual regression coefficient for prior steering wheel game use ($\beta = 0.28$, $t(69) = 2.03$, $p < 0.05$) achieved significance. No other coefficient was significant.

In the second step, perceived controller naturalness was added to the model. This block significantly increased variance accounted for, $R^2\Delta = 0.19$, $F(1, 68) = 24.07$, $p < 0.01$. Significant regression coefficients were found for perceived controller naturalness ($\beta = 0.47$, $t(68) = 4.91$, $p < 0.01$) and skill level ($\beta = 0.36$, $t(68) = 2.29$, $p < 0.05$). The important role of perceived controller naturalness in predicting spatial presence again supported Hypothesis 2.

Spatial presence and other predictors of game enjoyment

Hypothesis 3, which stated that spatial presence predicts enjoyment, was not supported, as in Study one. This hypothesis was tested by regressing the variables used in the prior hypothesis test and spatial presence on game enjoyment, in two blocks. The first block contained all variables except spatial presence, which was added in Block 2 to see if it would account for a significant portion of the variance on top of the other variables in the equation. Block 1 accounted for a significant portion of the variance in spatial presence, $R^2 = 0.50$, $F(8, 68) = 8.52$, $p < 0.01$. The individual regression coefficients for perceived controller naturalness ($\beta = 0.49$, $t(68) = 5.39$, $p < 0.01$) and prior driving game use ($\beta = 0.30$, $t(68) = 2.38$, $p < 0.05$) were significant. In Block 2, spatial presence was added to the model. This block did not significantly increase variance accounted for, $R^2\Delta$ $=0.02$, $F(1, 67) = 2.89$, $p < 0.10$, contrary to expectations.

Research Question 1 inquired about predictors of game enjoyment. Block 2, with all study variables, accounted for a significant portion of the variance in enjoyment, $R^2 = 0.52$, $F(9, 67) = 8.11$, $p < 0.01$. Significant regression coefficients included perceived controller naturalness ($\beta = 0.40$, $t(67) = 5.39$, $p < 0.01$) and prior driving game use ($\beta = 0.30$, $t(67) = 2.42$, $p < 0.05$). Predictors that approached significance included prior game use ($\beta = 0.19$, $t(67) = 1.75$, $p = 0.08$) and spatial presence ($\beta = 0.19$, $t(67) = 1.70$, $p = 0.94$).

An alternative view: path analysis results

Once again, path analysis was performed on the hypothesized variables, in the same manner as in the first study. The only exception is that the mapped interface variable was dummy coded with the driving wheel condition as '1' and all other conditions as '0.'

Results for the model are shown in Figure 3. All paths were significant this time. Controller type influenced perceived naturalness, with a path coefficient of 0.43, $P(0.21 < \rho < 0.65) = 0.95$. Perceived naturalness increased both spatial presence, with a path coefficient of 0.63, $P(0.43 < \rho < 0.83) = 0.95$), and enjoyment, with a path coefficient of 0.46, $P(0.19 < \rho < 0.73) = 0.95$). Enjoyment was predicted by spatial presence this time, with a path coefficient of 0.28, $P(0.01 < \rho < 0.55) = 0.95$).

The differences between predicted and obtained correlations for all unconstrained bivariate relationships were examined, and none were significantly different than what would be expected through sampling error. The model also passed the overall fit test, χ^2 (2) = 1.07, $p = 0.59$.

Discussion

This investigation began with the expectation that natural mapping would both directly and indirectly impact outcomes of video game play, including perceived controller naturalness, spatial presence, and enjoyment. Findings were generally consistent with predictions across two studies, lending preliminary empirical support to claims that

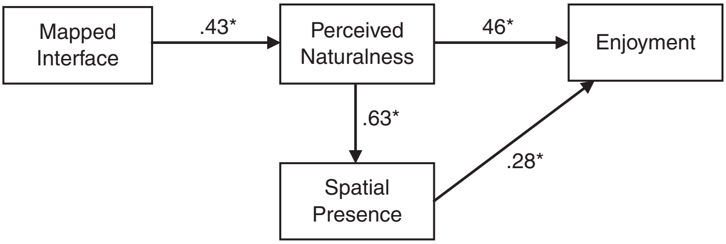

Figure 3. Results for Study two
$* = p < .05$
χ^2 (2) = 1.07, $p = .585$

mapping may 'radically' change how consumers respond to electronic games (e.g. *The Economist*, 2006). Specifically, participants in both studies who played using a controller offering tangible mapping reported more perceived controller naturalness than those who played using a variety of directionally mapped controllers. More importantly, even though spatial presence did not relate to game enjoyment as expected in both studies, perceived controller naturalness was a positive predictor of both spatial presence *and* game enjoyment. In addition, the results of the Study two path analysis suggest that realistic tangible natural mapping can create a sense of spatial presence that directly impacts enjoyment, completely consistent with expectations.

Playing with power: implications of natural mapping

This research suggests that natural mapping may be a powerful determinant of responses to video game technology. It answers the call of Lee and Peng (2006) and others to examine form variables in video games such as interactivity instead of focusing strictly on content, as has the majority of traditional media research. Natural mapping is a type of interactivity with the potential to make users perceive interactive control devices to be more natural, as the present findings indicate. Although this investigation only examined three types of naturally mapped interfaces, the conceptualization and measurement of perceived controller naturalness introduced here is broad, and has implications for a wide-range of mapping experiences. Defining and measuring natural mapping as a concept that varies along a continuum instead of as a discrete feature of distinct technologies allows for an understanding of natural mapping's influence on user experience that spans both present and future interface technologies.

Future research should attempt to determine how closely perceived controller naturalness and presence dimensions are related. Several presence scholars suggest that naturalness *is* a presence dimension (e.g. Lombard and Ditton, 1997; Lessiter et al., 2000), but most standardized measures of presence only tap content naturalness and do not tap form naturalness (presumably to remain applicable to non-interactive media experiences). Given the growing use of mapping in the video game industry and elsewhere, some attempt should be made to reconcile perceived controller naturalness and presence dimensions to better account for their joint impact on outcomes of media exposure.

This work also proposed several types of mapping – directional natural mapping, kinesic natural mapping, incomplete tangible natural mapping, and realistic tangible natural mapping – and these should be refined and more thoroughly investigated in future work. Although much attention has been focused on High Definition graphics of current generation gaming platforms (e.g. Bracken and Skalski, 2009), natural mapping seems to be an even more important new direction for gaming and one worthy of investigation, as the present findings suggest. Future work should attempt to define other types of mapping and investigate the relative importance of each to outcomes of game exposure such as presence sensations, game enjoyment, and prosocial and antisocial attitudes and behaviors.

Impacts on spatial presence and enjoyment

This research examined two potential outcomes of natural mapping – spatial presence and enjoyment – and found both to be affected by perceived controller naturalness. The finding that perceived controller naturalness strongly and positively predicts spatial presence was in line with expectations. However, the strong direct effect of perceived controller naturalness on enjoyment was unexpected. The importance of perceived controller naturalness may simply indicate that perceived controller naturalness and spatial presence are both dimensions of presence, as discussed above. Alternatively, spatial presence may not be as important to enjoyment as other variables, such as content interest. The findings of this study suggest that players do not need to feel spatially present in game worlds to enjoy them. Future research should examine if this varies as a function of variables such as game genre, however. Perhaps players want to feel spatially present in some types of games and genres but not others. Consistent with this idea, the present research found a stronger relationship between presence and enjoyment with the driving game than the golf game.

Regardless of the role of spatial presence, the findings of both studies confirm the expected importance of perceived naturalness to outcomes of video game play and suggest that more naturally mapped interfaces that are capable of generating even higher levels of perceived naturalness will be especially enjoyed by players in the future. The other consistently positive predictor of enjoyment was prior use of games from the same genre. This intuitive finding indicates that genre preference impacts players' responses to games and lends more support to the consistent finding in game research that prior game use predicts exposure outcomes (e.g. Tamborini et al., 2004).

Potential moderators of the mapping effect

Although the present study establishes a foundation for research on natural mapping-related reactions to video game technology, several questions remain unanswered, particularly about moderators of mapping effects. First, how does *time* affect perceived controller naturalness? Even though some interfaces may lack natural mapping on the surface, they may become more 'natural' over time as a function of repeated use. Second, do all game genres lend themselves to natural mapping, and if not, which are most and least likely to benefit from it? As Poole (2000) points out, very close mapping can sometimes even take away from the fantasy of engaging in amazing activities in video games, such as super-heroic moves and powers, given that people cannot perform those actions in real life. Third, do all players even want mapping? Some have suggested, for example, that the highly mapped Nintendo Wii appeals more to casual than 'hardcore' gamers (e.g. *The Economist*, 2006), and future work should attempt to address the relationship between player type, game type, and mapping.

Long-term implications of natural mapping

The important role of game mapping revealed in this research points to the exciting potential of naturally mapped controllers, both in gaming and in other contexts. Natural mapping and resulting spatial presence may not only positively impact video game enjoyment, but also other positive outcomes such as training. In the case of training, natural mapping in simulators can provide users with a more complete mental model for how to perform the real-life actions they are learning, resulting in greater skills transference (Skalski et al., 2002). At the same time, the downside of natural mapping must also be addressed. If natural mapping can enhance the learning of prosocial skills, it can also create stronger mental models for antisocial behavior, such as firing a weapon or punching and kicking, as players of highly-mapped violent video games might do (Tamborini and Skalski, 2006). Future work should address the many possible outcomes of natural mapping in an attempt to better understand this important and increasingly popular feature of video game technology.

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