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It's not the model that doesn't fit, it's the controller! The role of cognitive skills in understanding the links between natural mapping, performance, and enjoyment of console video games

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It’s not the model that doesn’t fit, it’s the controller! The role of cognitive skills in understanding the links between natural mapping, performance, and enjoyment of console video games

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Abstract

This study examines differences in performance, frustration, and game ratings of individuals playing first person shooter video games using two different controllers (motion controller and a traditional, pushbutton controller) in a within-subjects, randomized order design. Structural equation modeling was used to demonstrate that cognitive skills such as mental rotation ability and eye/hand coordination predicted performance for both controllers, but the motion control was significantly more frustrating. Moreover, increased performance was only related to game ratings for the traditional controller input. We interpret these data as evidence that, contrary to the assumption that motion controlled interfaces are more naturally mapped than traditional push-button controllers, the traditional controller was more naturally mapped as an interface for gameplay.

1. Introduction

Imagine Jack and Jill. Jack and Jill both own different video game systems, and they want to play the latest first-person shooter video games. They purchase similar versions of the same game franchise (such as Infinity Ward’s *Call of Duty* games), and go to their respective homes to try out their new games. Jack and Jill are about equal in video game skill, have similar tastes in games, and have similar playing habits and experience. The next time Jack sees Jill, Jack expresses how much he loves the new game and how much he’s enjoyed playing it. Jill, dumbfounded, claims the game was frustrating and too difficult. Jack and Jill feel so differently about their experiences, they even wonder if they were playing the same type of game. Through their conversation, they discover that they were playing the same game but they make a stark realization: Jack was playing with a traditional video game controller and Jill was using a motion-sensor controller. As a result, Jack was able to use his video game skills and apply them directly to beating the on-screen challenges, but Jill – although expecting a more natural experience using her own motions as the game inputs – had to spend a lot more time learning a new control scheme and, as a result, she was unable to devote as much time to enjoying the game. Jill explained that the controllers for her console were supposed to be more ‘‘natural,’’ but now, both of them wonder what that means for the video game experience.

Games vary on many dimensions, such as graphics and gameplay, but one dimension germane to the current empirical investigation is the controller used for the game – the device, either wired or wireless, held by the gamer and used to manipulate on-screen objects and characters. Each video game console uses a different controller, and games often allow players to use different controller schemes and layouts based on their personal preferences. Importantly, the enjoyment of a game can be tied to which type of controller is used (Joeckel & Bowman, 2012), and some even argue that the aesthetics and ergonomics of the controller are a qualitative part of the gaming experience (Cummings, 2007).

Notably, console game controllers are shifting toward motioncontrolled interfaces, as opposed to traditional push-button controllers. The three major seventh-generation video game consoles have each implemented motion control devices (Nintendo Wii, Playstation Move and Xbox Kinect), and the newest eighth-generation console, Xbox One, includes advanced motion-control computing technology as a central feature of game design. Based on this trend toward motion-controlled interfaces, it is worth developing an understanding of how differences in controller type can have diverging impact on the end-user experience of gameplay. Developers seem to be assuming that enhancing the perceived naturalness of a control scheme (such as using the human perceptual system to control on-screen action rather than a push-button system) should automatically enhance a game's playability and resultant enjoyment, but quick scans of game reviews (Alam, 2008; Tamborini & Bowman, 2010) have found that individual game ratings for Nintendo Wii titles, on average, fall considerably behind their traditional-controller counterparts. To this end, our study will examine the difference between players performance, frustration and game rating as predicted based on use of a motion controller and traditional controller.

2. Mapping and natural mapping in video games

Often, motion-controlled interfaces require players to physically mimic the actions to be performed in the game. For example, some games in the *Call of Duty* franchise, a first person shooter, requires the player ‘‘aim’’ and ‘‘shoot’’ in their living room as the motion-control device tracks the players' body movements. Meanwhile, other games in the *CoD* franchise do not use a motion-controlled interface but rather a traditional controller where button presses cause the player's avatar to perform a variety of actions.

The difference between these interfaces can be described as a difference in mapping, or a match between virtual actions and natural actions in the world (Reeves & Read, 2009). Broadly, mapping is an interface design attribute. Natural mapping – a specific type of mapping involving consideration for the natural human perceptual system (Biocca, 1997) – is achieved when an interface's controls correspond to their actual physical actions (Norman, 1988). Norman (1988) suggests that when interface controls are highly naturally mapped, they should be intuitive to the extent that labeling the controls is unnecessary; Clark (2003) refers to this phenomenon as an indication of transparent technology – one that is used without consideration.

Skalski, Tamborini, Shelton, Buncher, and Lindmark (2011) suggest that realistic tangible mapping is the most natural. Realistic tangible models should most closely mirror real-world action and therefore allow users to readily access mental models associated with those actions

(Tamborini & Skalski, 2006). In other words, mapping creates isomorphism between a controller action and the action on screen (Norman, 1988), reducing awareness of the controller and enhancing spatial presence (a psychological sense of feeling physically part of a virtual environment; Tamborini & Bowman, 2010). In a sense, highly naturally mapped controllers do not require users to learn new mental models in order to be effectively used.

The connection between natural mapping and interactivity is well documented (Reeves & Read, 2009; Skalski et al., 2011). Generally, it is accepted that natural mapping leads to perceptions of interactivity (Reeves & Read, 2009). Perceptions of interactivity lead to feelings of immersion and telepresence (Smith & Graham, 2006; Steuer, 1992; Tamborini et al., 2004) as well as positive attitudes toward content, more engagement with content, and retention of content (Ariely, 2000; Sundar & Kim, 2005; Teo, Oh, Liu, & Wei, 2003).

Further, mapping has been connected to enjoyment. Skalski et al. (2011) demonstrated that natural mapping led to more perceived naturalness which led to enjoyment. Tamborini, Bowman, Eden, Grizzard, and Organ (2010) provided evidence that natural mapping in a bowling video game had a positive relationship with intrinsic needs, such as competence and autonomy, and players derived enjoyment from the satisfaction of those intrinsic needs.

However, in the context of video games, we argue that mapping might function differently than what has been suggested in the preceding literature. In fact, we predict the opposite pattern will emerge. Namely, when controls are closely mapped to mirror real-world actions in video games, they will be considered less ‘‘natural’’ than when actions are mapped to presses of a button on a traditional controller. For example, many video games feature extraordinary settings and circumstances, like magic and monsters in *World of Warcraft* or aliens and spacecraft in Halo. Therefore, many of the actions in the games have no real-world analogue, like casting a healing spell or flying a fictional vehicle. We should not expect players of these games to have strong mental models or accurate reference points for these behaviors.

Consequently, while players do not have a strong mental model of these physical behaviors named above – casting spells and fighting enemy insurgents – they may have a strong mental model of these behaviors when playing video games. If it is the case that players’ mental models of these behaviors are more a function of their video game experiences than their real-world experiences, then it makes sense that traditional push-button controllers might be perceived as more mapped for the mental model of playing a video game war simulator. Moreover, most video games – regardless of how realistic they are programmed to be – are rarely authentic to the actions they are portraying. Game designers focus more on presenting an idealized version of otherwise-banal activities that can be romanticized (Farokhmanesh, 2013). In some respects, players’ reactions to so-called naturally mapped game controllers might even be understood in terms of Mori’s (1970) uncanny valley, which suggests that as virtual activities become more similar to their real-world analogies, audiences’ reactions become increasingly negative when those virtual actions are not able to fully match the real-world.

3. Video games and flow experiences

In their exploratory model of play, Csikszentmihalyi and Bennett (1971) attempted to identify the psychological motivations for playing games. Across several different cultures, the authors found evidence of games and other forms of play that seemed to serve no purpose beyond the activities themselves. These autotelic (re: self-motivated) activities were found to be intrinsically enjoyable because they provided enough of a challenge to be self-perpetuating while not over-taxing the skills of the players. The result of this optimal balancing of challenge and skill was the flow state—a self-motivated state of immersion and loss of self that results in optimal levels of enjoyment (Csikszentmihalyi, 1993; Nakamura & Csikszentmihalyi, 2002). Expanding the notion of flow to understand media enjoyment, both Sherry (2006) and Hsu and Lu (2004) argued that video games, among other entertainment products, are an ideal medium for inducing flow experiences given that elements of challenge and skill are so core to their design.

As specifically outlined by Sherry (2006), flow in video games can be understood as the optimal balance of challenge and skill that sits between frustration (challenge outweighs skill) and boredom (skill outweighs challenge). Recent evidence suggests that frustration elicited by video games can provoke aggressive affect, thoughts and behaviors (Przybylski, Deci, Rigby, & Ryan, 2014). Notably, this effect was found regardless of the level of violence in the game played. Accordingly, attention to frustration is important in present and forthcoming video game research.

Past work (Bowman, Weber, Tamborini, & Sherry, 2013; Sherry, Rosaen, Bowman, & Huh, 2006) has demonstrated that we can also understand players' flow experiences by analyzing their cognitive abilities as indicators of game skill. Sherry et al. (2006) demonstrated that game-related cognitive skills – such as verbal fluency when playing a word-puzzle game, memorization when playing a surveillance game, and mental rotation ability when playing a three-dimensional maze game – were significant predictors of both performance and flow experiences. In fact, cognitive skill variance was a stronger predictor of game performance and flow than individual differences such as gender and prior game experience, suggesting that ''there is more to the game experience than simply content enjoyment...unlike television and film, successful gameplay requires particular skills that vary across human populations (p. 10).''

It is reasonable to expect that using a certain type of controller could also influence the flow experiences of a given game. Based on gamers' skill or game content, a motion-controlled device might be easier or more difficult to use that a non-motion controlled device and thus, more or less enjoyable. While not focused on flow and enjoyment per se, Bowman et al. (2013) found that cognitive skills such as mental rotation (both two- and three-dimensional) as well as eye–hand coordination and targeting ability (both fixed and moving targeting) were direct significant predictors of game score in a first-person shooter, as well as indirect predictors of enjoyment of the same (as mediated by game score). Early work comparing controller types (traditional and Wii motion-sensor controllers) by Bowman and Boyan (2008) found evidence that different cognitive abilities were more aligned with different controllers, such as fine motor skill being more relevant for a traditional game controller and eye/hand coordination being more relevant for a motion-capture device. Taken together, these studies suggest that an individual's cognitive abilities are associated with their ability to play a video game, which can impact the attainment of an optimal flow state.

4. Method

In this study, participants played two versions from the firstperson shooter series *Call of Duty* with two different video game controllers on the same game console (a Nintendo Wii). One controller was a Nintendo Wii controller (motion-controlled) and the other was a Nintendo GameCube controller (traditional buttonpress controller); both controllers are compatible with the Nintendo Wii system. The order in which the games were played was randomized, and a buffer task of playing another video game (*Quake 3: Arena*) was used between sessions of *CoD*. Data from the buffer task was analyzed for an unrelated study, but the purpose of the buffer task in the current study was to help protect against any learning effects from playing either version of *CoD* in succession. For the buffer task, players also used different gaming interface (keyboard and mouse) than either *CoD* gaming session. Following each 10-min gameplay session, participants were asked to report on their recollection of in-game flows states (notably, feelings of frustration) as well as to provide an overall rating of the game. In-game performance was also noted by recording how many objectives each player was able to complete, as well as the number of times they were killed by enemy soldiers. Player's cognitive abilities were assessed in earlier pre-screening study.

5. Stimulus

Two games from the *CoD* series, *Call of Duty 2: The Big Red One* (*CoD2*) and *Call of Duty 3* (*CoD3*) were chosen due to their close release dates to one another (less than six months separated the last version of *CoD2* and the first version of *CoD3*), and their compatibility with the Nintendo Wii system. In particular, although *CoD2* was initially released for the GameCube, the Wii console is backwards-compatible with GameCube games and is able to play them in an enhanced mode by using progressive digital upscanning techniques (while both systems have similar processors, the GameCube display output is limited to 240 pixels while the Wii can render in 480 pixels). Choosing two games with a short time delay between their release dates as well as using upscanning technology to re-render the older game (*CoD2*) with higher resolution graphics (240–480 pixels) allowed us to protect against potential differences in game quality. In addition, both games received similar ratings from popular industry publications (*CoD 3*: IGN rating of 8/10, Metacritic score = 69 of 100; *CoD 2*: IGN rating 8/10, Metacritic score = 76 of 100). Indeed, the *CoD* franchise is often at once praised and criticized for releasing nearly-identical games across several platforms – usually making minor tweaks to missions and player options (in particular, multiplayer options) rather than releasing qualitatively different titles from one release to the next (cf. Ruscher, 2013). The difficultly level for both games was set at the game-default ‘‘normal’’ in hopes of offering a moderate challenge for novice and experiences gamers alike.

We note here that the use of separate games, despite their structural and content similarities as well as, introduces a potential confound in that the games cannot be assumed equivalent on all possible variables; they are – after all – different games. However, while some console and PC games can be easily altered to accept multiple controller inputs (for example, most PC games allow one to choose a keyboard and mouse interface or a traditional game controller), games that take advantage of motion-sensor technology rarely have this option. One reason given for this lies in the nature of the control input itself – programming a video game to accept digital (or even analog) signals from a button-press controller is a simple binary command (‘‘on’’ to activate a given command, ‘‘off’’ to deactivate it) while programming for a motion-sensor controller often requires a far more complex system of calculations (for example, processing rapid-succession binary commands that correspond to output from an embedded accelerometer to activate or deactivate a given command). Besides the structural difference in programming traditional compared to motion-sensor/‘‘naturally mapped’’ controllers (a full discussion of which is beyond the scope of this paper), the nature of each control input also informs what the programmer can or cannot eventually include into a given gameplay experience, which results in the development of unique motion-sensor video games that are not released in other formats or for non-motion sensor consoles (cf. Mackey, 2010). A quick scan of the top-selling Wii titles globally (VGChartz.com, 2014) shows that the top seven titles are (a) unique to the system and (b) all integrate motion-sensor controls as a core gameplay mechanic. For these reasons, we are confident that our use of *CoD2* and *CoD3* offer a near-optimal balance of equivalent game experiences (released less than six months from each other, from the same developer and largely replicating each other’s core game mechanics) while still manipulating the focal variable of our study (using a traditional push-button or a naturally-mapped controller to operate key game mechanics). Fig. 1 illustrates the controller layouts for both games.

Both *CoD2* and *CoD3* place the player in the midst of a World War II battle using identical weapons (iron-sight M1 Garand rifles and basic impact grenades). Both games are situated in the north of France, in the Summer and Fall of 1944 (*CoD2* in northern Maubeuge, and *CoD3* in northwestern Saint-Lô). In both missions, the player is placed in the middle of an active battle, facing infantry, heavy artillery, and air bombing threats. Each of the missions is an integrated training mission, with the player being given a series of nominal tasks in the beginning to help familiarize them with the controls. For *CoD3* (the Wii-native game), players were given time to fire at non-threatening targets (helmets on a post) before advancing to the battle scene; this was done to allow them time to learn the mechanics of the motion-sensor controller (see Fig. 2).

6. Manipulation

In both versions of *CoD*, the player was responsible for the same mechanics of gameplay – aiming, shooting, reloading and changing weapons, navigating, and maneuvering the battlefield being chief among them. However, the manner in which these mechanics was engaged differed widely between both games, not as function of game design but rather, as a function of controller input. For example, to fire a rifle with the traditional controller, players had to manipulate a yellow analog joystick on the right of the controller with their thumb (to track the target), hold down the topleft gray trigger with their left index finger (to zoom in on the target), and press the top-right gray trigger with their right index finger (to fire the rifle). With the motion-sensor remote, players aimed by holding the remote in their dominant hand and pointing it toward the television set (to track the target), pressing down on a clear button on top of the remote (to zoom in on the target), and pulling the trigger button on the bottom of the remote with their index finger (to fire the rifle).

Fig. 1 Different input-output commands to fire a rifle in CoD, comparing traditional GameCube controller (top) and motion-sensor Wiimote (bottom).

Fig. 2. Sample game images from CoD2 (left) and CoD3 (right); both images are taken from the first mission of each game (Maubeuge for CoD2 and Saint-Lô for CoD3).

7. Participants

Ninety-one ($N = 91$) participants were recruited from a large, Midwestern university. The majority of participants were women (57.10%), Caucasian (71.40%), and between the ages of 19 and 22 years old (80.30%), $M = 21.10$, $SD = 1.81$.

8. Measures

8.1. Cognitive skill

Participants' cognitive abilities were assessed using protocol established by Bowman et al. (2013) in which participants are pre-screened for their ability to complete a series of tasks, including two-dimensional and three-dimensional rotation tests (paper and pencil tests), a fixed and moving targeting ability task (involving participants tossing a tennis ball, underhanded, at a fixed or moving target), a fine motor skill task (participants were asked to remove and replace pegs from a triangular block of wood as fast as possible), and an eye–hand coordination test (participants were asked to catch a yardstick suspended from a tall ceiling).

The correlations between cognitive skill measures were tested. The two-dimensional and three-dimensional rotation tests were significantly correlated ($r = .53$, $p < .001$). The two-dimensional rotation test was also significantly correlated with the eye–hand coordination test ($r = .35$, $p < .01$).

8.2. Video game performance

A performance score was created by calculating the number of in-game objectives each player was able to accomplish in *CoD* (objectives included advancing to specific points on the game's level map), minus the number of times a player was killed while trying to accomplish these objectives.

8.3. Frustration

A version of Sherry et al.'s (2006) media flow scale was used, measuring recollections related to feelings of frustration (an overbalance of challenge over skill), boredom (an overbalance of skill over challenge) and flow (an optimal pairing of challenge and skill). For data analysis, our focus was on the influence of controller scheme on frustration. Three frustration items (''This game was very irritating to play,'' ''I found this game difficult to play'' and ''This game was too complicated for me to play.'') were averaged (GameCube $a = .80$, $a =$ Wii, .79).

8.4. Game rating

To avoid issues of multicollinearity associated with measuring enjoyment as an outcome of flow states (Bowman, 2008; Sherry et al., 2006), participants were asked to rate on a scale of ''1'' (lowest) to ''10'' (highest) the overall quality of both games *CoD*.

9. Results

Paired-samples *t*-tests found performance to be significantly higher for the GameCube condition ($M = 3.51$, $SD = 5.28$) than the Wii condition ($M = 3.77$, $SD = 5.09$), $t(87) = 11.80$, $p < .001$, Cohen's $d = 2.53$, effect size $r = .78$. Similarly, frustration scores were significantly higher when playing with the Wiimote ($M = 4.82$, $SD = 1.45$) than the GameCube controller ($M = 3.90$, $SD =$

1.46), $t(87) = 5.33$, $p < .001$, Cohen's $d = 1.14$, effect size $r = .50$. However, the game ratings did not differ significantly between the two conditions (GameCube $M = 5.86$, $SD = 2.40$; Wii $M = 5.67$, $SD = 2.52$, $t(87) = .87$, $p = .384$, Cohen's $d = .19$, effect size $r = .09$). In order to more adequately explore these findings we employed structural equation models.

Based on the previous literature we suggest the following model of natural mapping and enjoyment (Fig. 3). The degree of natural mapping a particular controller imbues can be addressed by first examining cognitive skills, then demonstrating how those skills ‘‘map’’ onto game performance. This is a method for showing how ‘‘natural’’ using a certain controller in a game might be. Then, game performance should impact attitude toward the game and the level of frustration a player feels. If a player performs well, then he or she will likely feel less frustration and enjoy the game more. Conversely, if a player performs poorly, he or she will be more frustrated and enjoy the game less.

To examine the difference between a motion controller and a traditional controller we ran structural equation models with the proposed model twice. Once examining variables related to the motion controller and once with variables related to the traditional controller (Figs. 4 and 5, respectively). All exogenous variables were allowed to covary. The proposed model for the traditional controller showed an adequate level of fit, X^2 (28) = 35.16, $p = .16$, CFI = .97, RMSEA = .05. The model for the motion controller demonstrated significantly worse fit, X^2 (28) = 68.82, $p < .001$, CFI = .83, RMSEA = .13.

Regarding cognitive ability, both models show similar patterns in that game performance was predicted by the same set of cognitive skills: three-dimensional rotation ability, fixed targeting ability, and moving targeting ability. However, the relative strength of these skill-performance associations varied somewhat across controller conditions. For the traditional controller, moving targeting ability was the strongest predictor of performance ($\beta = .32$, SE = .168, $p < .001$) as compared to the motion controller ($\beta = .18$, SE = .164, $p < .001$). Also in the motion controller model, three-dimensional rotation ability and moving targeting ability did not predict performance as strongly, while fixed targeting ability predicted performance more strongly ($\beta = .27$, SE = .109, $p = .002$) than in the traditional model ($\beta = .20$, SE = .150, $p = .033$).

In terms of frustration, increased game performance was a significant negative predictor of self-reported frustration, but this effect is weaker for the motion controller ($\beta = .48$, SE = .023, $p < .001$) than for the traditional controller ($\beta = .44$, SE = .032, $p < .001$). Performance also served as a direct positive predictor of game rating in the traditional controller model ($\beta = .38$, SE = .042, $p < .001$) but not in the motion controller model ($\beta = .16$, SE = .051, $p = .129$. For the motion controller, performance only had an indirect impact on game rating as a function of frustration. Increased frustration negatively predicted game rating when using both controllers, and this relationship was stronger in the motion controller model ($\beta = .58$, SE = .361, $p < .001$) than in the traditional controller ($\beta = .42$, SE = .171, $p < .001$).

10. Discussion

The key findings from this study lay in the fact that the two structural equation models had such substantially different fit, with the traditional controller model having a much better fit than the

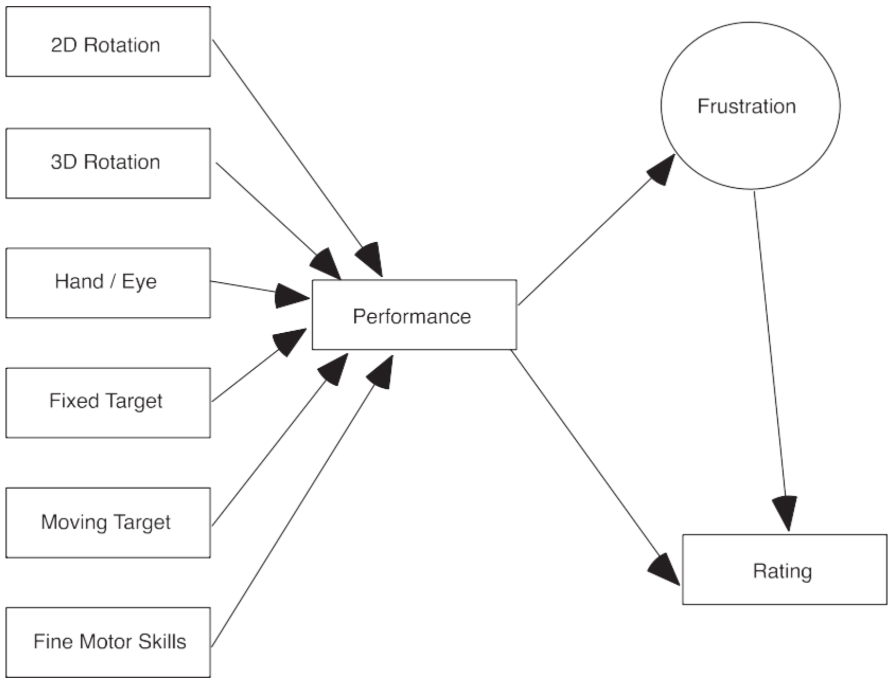

Fig. 3. Proposed model tested for motion controller and traditional controller.

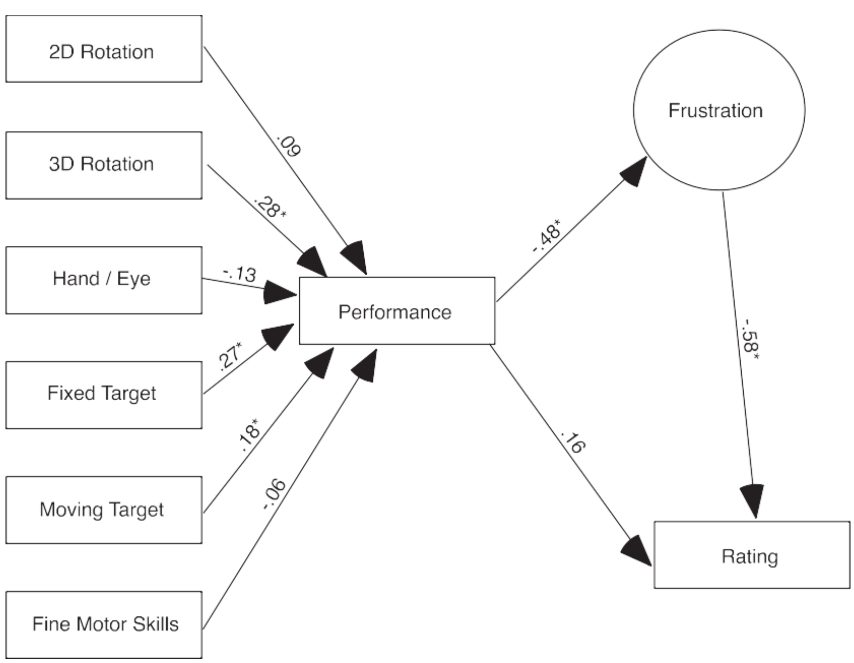

Fig. 4. Model for motion controller, standardized regression coefficients shown. v2 (28) = 68.82, p < .001, CFI = .83, RMSEA = .13.⁄indicates p < .05 or greater.

motion control model. The use of motion control interfaces cannot adequately explain users' enjoyment of a first-person shooter. Notably, this indicates that the motion control in this study is not naturally mapped – or at least, not nearly as mapped as it has been assumed to be. Conversely, the traditional controller model more thoroughly explains variance in game rating, perhaps because it does not introduce as many 'extraneous' variables. For example, there could be other cognitive skills that more directly address the Wii controller instead of the GameCube controller. Also, there could be general frustration with the learning curve associated with a ''novel ''controller such as the Wii remote. In other words, this finding challenges previous investigations of mapping in video games that suggest motion controls are more naturally mapped than push button controllers.

While it might seem ''natural'' to hold the Wii controller as a gun and shoot accordingly, this assumes that the target audience really does understand the mechanics and processes of gun-based targeting and can map this onto an artificial Wii remote/nunchuck control scheme. Indeed, shooting with one hand and using one's thumb to move with another might be far less naturally mapped than a traditional controller. In terms of the typology put forth by Skalski et al. (2011), this Wii control scheme is a melding of incomplete tangible natural mapping and directional natural mapping, neither of which provide a complete mental model of the experience. Perhaps this generates competing mental models and results in a more foreign, rather than familiar, interface. Combining this incomplete mental model with the audience's likely inexperience with battle combat results in a control scheme divorced both from the authentic experience of a live-ammunition

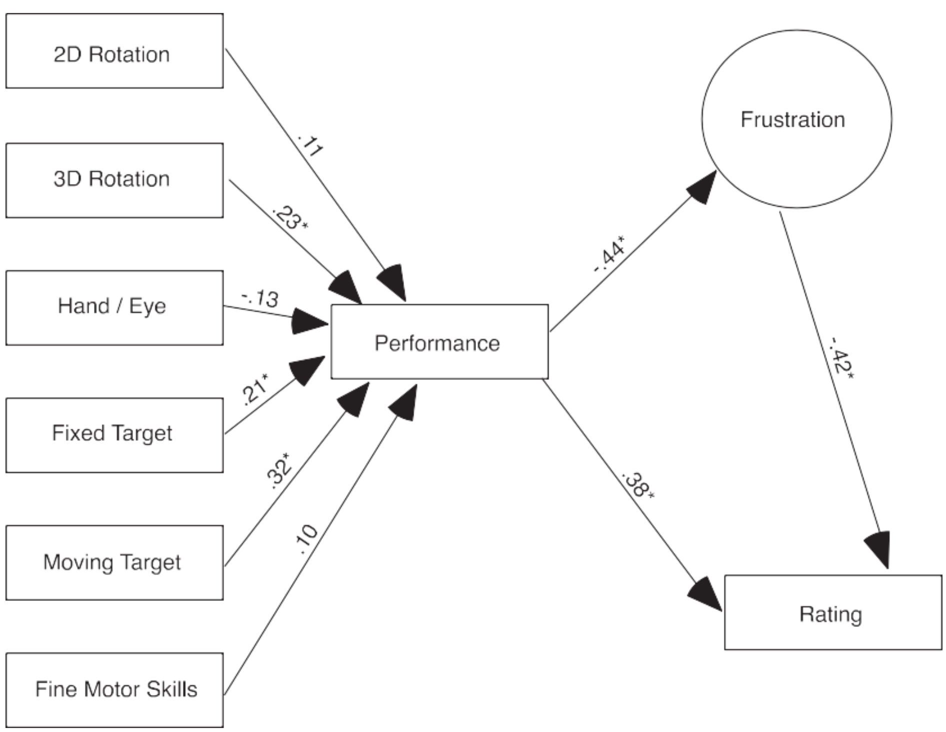

Fig. 5. Model for traditional controller, standardized regression coefficients shown. v2 (28) = 35.16, p = .16, CFI = .97, RMSEA = .05.⁄ indicates p < .05 or greater.

firefight as well as the realistic experience of pretending to engage a firefight in video games.

To this point, we have discussed the difference in fit between the two models. Yet, serial impacts of each of the different speci- fied paths in our study emerged and provide evidence that these controllers are mapped differently. Findings in this study suggest that the cognitive skills used to play a game vary somewhat based on the type of controller used. Specifically, performance with the traditional controller was most strongly predicted by moving targeting ability while fixed targeting ability most strongly predicted performance with a motion controller. While the same general cognitive skills served as broad predictors of performance, the fact that some skills were more or less predictive suggests that different control mechanisms might be tapping into different cognitive skills – results similar to prior work (Bowman & Boyan, 2008). These patterns demonstrate that use of these controllers is not equal in terms of natural mapping. It seems plausible that fixed targeting ability was more important to predicting performance with the motion controller because, in order to track targets and fire at them, the player was required to aim a handheld remote from a perspective outside of the television screen itself. From such a perspective, while the individual targets would have been moving around on-screen, the player would have needed to have the ability to steady a handheld remote control at a static computer screen in order to execute a successful shot. Conversely, a traditional controller requires the player to precisely manipulate a targeting reticle (the traditional controller's substitute for the barrel of a gun, displayed on-screen) from a perspective within the game space itself – that is, players using the GameCube controller needed to constantly move and adjust the targeting reticle in relation to other in-game objects and targets in order to track their trajectory and fire slightly ahead or behind of those targets in order to execute a successful shot. In this way, we might expect a player using a traditional controller to perceive the in-game content to be moving much more than when the targets are displayed simultaneously on a stationary screen. Notably, such a conclusion does not rule out the role of moving targeting ability in the success of motion-sensor controller play or the role of fixed targeting in the success of traditional controller play, but it does offer a logical explanation for the variable influence of these skills on performance as witnessed in the current study.

Similarly, the finding that three-dimensional rotation ability was a stronger predictor of performance with a traditional controller as opposed to a motion controller suggests that the use of joysticks and buttons rely on spatial skills that go beyond pointing a controller at a screen. As with the targeting skill differences, this data indicates the player had to think three dimensionally when using a traditional controller more so than when using a motion controller. Recall that the definition of three-dimensional mental rotation ability is the skill one has at imagining what a three-dimensional object would look like from various different angles (Kimura, 1999). Three dimensional mental rotation skills are less important when a player uses a motion control because the player does not have to mentally render on-screen content from the game world since they are controlling the action from outside the screen, using more or less natural space that exists outside of their mind. While the same cognitive skills showed some predictive power in explaining game performance, the differences in their predictive power point toward differences in mapping.

Lastly, frustration negatively predicted game rating such that more frustration led to worse ratings. Notably, these feelings were more exaggerated for the motion controller, with frustration's impact on game rating stronger for the motion controller ($\beta = .58$, $p < .001$) than it was for the traditional controller ($\beta = .42$, $p < .001$). These data suggest that players simply did not like using the motion controller, possibly because they have no mental model for using it. Further support for this conclusion can be found in the fact that performance – a variable already established as a key factor in the positive rating of a video game (Bowman & Boyan, 2008) – was a stronger predictor of frustration for the traditional controller, and game rating was not predicted at all by performance while using a motion controller. This could suggest that players may not expect to do well when using a motion controller. When players use a unique interface, they might temper their expectations in terms of performance. However, when players do have a stronger mental model such as when using a traditional controller, they might expect to perform at higher levels and therefore become more frustrated when they do not. At the same time, over 40% ($n = 39$) of the participants in our study were not regular video game players, and another 32% ($n = 30$) reported playing less than one hour weekly.

11. Limitations

As with any social science research, this study has limitations that deserve our consideration. The use of a within-subjects design results in data dependency. However, the order of these games was randomly assigned for all participants, and each participant was given a buffer in-between the Wii and GameCube sessions. In addition, the buffer games were played using a mouse and keyboard interface – a control scheme qualitatively different from those used in the study proper (cf. Gerling, Klauser, & Niesenhaus, 2011). As a result, it is unlikely that participants could transfer skills from so many different game experiences. Participants were also limited in the amount of time they were given to play the games – less than 20 total minutes, and only 10 with each game.

Further, the scope of this study is fairly narrow as it only addresses one game series (*CoD*) and one genre (the first-person shooter) using a specific motion-sensor controller (the Wiimote). Future work would need to replicate the models in this study with other configurations of games, and possibly consider a broader range of cognitive skills. Other motion controllers might tap into these schools more adequately than the Wiimote. It would also be beneficial to explore games that feature real-life actions perhaps more accessible or familiar to players (e.g., bowling, tennis) which might provide a more robust test as to the influence of mental models on gaming experiences. Also, future research might consider the task demand associated with different control mechanisms, as task demand is a known predictor of game performance and enjoyment (Bowman & Tamborini, 2012, 2015). It is plausible that a more natural interface should have less task demand, but only when the interface is compatible with a users' mental model of the behavior.

Ideally, this study would have implemented the same game for the motion controller and the traditional controller. This was not possible at the time of the current study, as there were no games available that allowed for a readily-swappable controller interface (i.e., playing the same game using a traditional controller or a motion-sensor one). However, we selected games on the market that were very similar on important dimensions besides their control scheme, such as graphics, narrative, and in-game actions, as well as their general quality (in our study, both games were rated by our as being of similar quality). This being said, future work should look for games that are ideally matched on all dimensions except for controller input that also allow for motion-sensor compared to traditional controllers. Likewise, it is possible that the findings here are the result of game difficulty, as the game could have simply been harder to play with a motion controller. Participants were able to complete 34% of the in-game objectives in the GameCube version of *Call of Duty*, but only 20% of objectives in the Wii version. At the same time, as many as 45% of Wii players had difficulty with the rifle mechanism (aiming at the screen to shoot enemies), which likely greatly hindered their ability to complete in-game objectives (as well as defend themselves) in a war simulation game. Of course, the fact that a game could be more or less difficult as a function of the controller used to play serves to further illustrate the importance of our findings.

12. Conclusion

In conclusion, this study provides a potential explanation to the Jack and Jill anecdote at the start of this paper. Jack, presumably, was using a traditional controller while Jill was using motion controller. In other words, Jack's controller was more naturally mapped to the act of video gameplay than Jill's, resulting in better performance and more favorable attitudes toward the game. Contrary to the assumption that motion controlled interfaces are more naturally mapped than traditional push button controllers, this study shows evidence of the inverse. Namely, when comparing two models of enjoyment of the gameplay with different control schemes, the traditional controller model demonstrates much better fit for game ratings (independent of game performance) than the motion controller. As a result, we conclude that for some video games, a traditional controller is more naturally mapped than a motion controller.

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