Multitasking, Presence & Self-Presence on the Wii

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Abstract

Previous research has shown that presence, self-presence, and multitasking all affect task performance, but these mechanisms have been tested in separate experiments. This study is one of the first to concurrently examine how the feeling of presence and self-presence while playing Nintendo Wii affects the ability to perform on various multitasking tasks. In a 2 x 2 between-subjects design, participants played Wii Tennis either with a Mii they created to resemble themselves or with a generic Mii. To make participants self-aware of their virtual or real selves, they were told that they were videotaped either on the screen or both on-screen and in the physical room. These two manipulations, Mii similarity and self-awareness, were found to significantly affect the participants' feelings of self-presence or presence, respectively, in the expected directions. These manipulations also significantly affected participants' behavioral performance on various multitasking tasks, including memory encoding and retrieval, and problem solving. These data demonstrate the importance of presence management and strategic avatar choice in multitasking scenarios.

Keywords--- **Presence, Self-Presence, Multitasking, Avatar, Self-Awareness, Nintendo Wii**

1. Introduction

Consider, briefly, that you are sitting on a couch, playing a video game in which your character is struggling to vanquish a seemingly unassailable enemy, when suddenly your phone, in the real world, rings. It's the pizza delivery person, lost and asking for directions. Instead of pausing the game, you continue your battle, simultaneously guiding your sword toward your enemy and the pizza toward your home. Left swing for the armor, "Right turn on Main Street." But as the skirmish heats up, does your ability to direct the delivery person waiver? As your character sustains damage, sending a twang of empathy through your real-world heart, do you temporarily forget about the rumblings of your real-world stomach?

As interactive media technology becomes more pervasive in the world around us, the need to balance our virtual and real-world endeavors becomes more apparent. The hypothetical situation above illustrates that finding such balance is dependent on various factors, including level of engagement with the virtual environment, also known as presence, and level of connection to one's virtual representation, also know as self-presence. The current work examines these two factors, presence and self-presence, in an attempt to contribute to an understanding of how concurrent virtual and real-world endeavors are negotiated. Such an understanding will hopefully be applicable to the design and implementation of virtual and real environments in ways that improve efficiency, safety and enjoyment within such environments.

2. Presence and Self-Presence as Results of Avatar Similarity and Self-Awareness

While various scholars have debated the definition and value of the concept of presence [1, 2, 3, 4, 5, 6, 7], the present study does not intend to contribute to such debates but instead will provide empirical research based on a definition of the concept that has emerged from such debates relatively unscathed. Namely, presence is treated here as the perception (or misperception) that a virtual experience is actually a real experience. Much presence-oriented empirical research utilizes high fidelity displays to create virtual environments that can be described as "virtual reality", but presence is not constrained by technology, and individuals can feel high levels of presence even while reading a book [5]. Hence, the present study examines the concept of presence using commonly available technologies that are usually not described as virtual reality, a television and a Nintendo Wii video game console.

The present study is particularly focused on a subcategory of presence known as self-presence, treated here as the extent to which a user feels that her avatar, or virtual representation of self inside a virtual world, is an extension of herself [1]. Previous research has shown that variance in representations of virtual selves results in differences in self-presence, such that virtual selves that are more similar to real selves induce greater feelings of self-presence than those that are less similar to real selves [8, 9]. Consistent with such research, in the present study the level of similarity between individuals and their avatars was varied as a means of manipulating the amount of self-presence that these individuals experience. Level of similarity was controlled by either having participants use an avatar they created in their own likeness or a generic looking avatar that was assigned to them. Participants in the former category were expected to experience more self-presence than participants in the latter. Further, because self-presence is intrinsically tied to the overarching concept of presence, participants in the former category were expected to experience more presence than participants in the latter.

Hypothesis 1a: Participants who use an avatar they have created in their own likeness will report feeling more *self-presence* than participants who use a pre-made avatar that is assigned to them.

Hypothesis 1b: Participants who use an avatar they have created in their own likeness will report feeling more *presence* than participants who use a pre-made avatar that is assigned to them.

Drawing from Hull and Levy's [10] assertion that self-awareness is a function of self-relevant information in an individual's social environment, differences in presence and self-presence are expected to result from differences in self-relevant information within either the virtual or real environment. Hull and Levy manipulated self-relevant information by either including or not including a mirror in a room while participants completed a written task and by telling participants that their answers either would or would not be scored with feedback provided. The present study used a similar mechanism. By indicating that the participant was videotaped on just the screen or on both the screen and in the physical room, we sought to induce participants to feel more self-aware within either the virtual or real environment, respectively. Because this mechanism relates to both the self and the environment, it was expected to affect presence as well as self-presence separately. Levels of presence and self-presence within the virtual environment were expected to vary depending on whether an individual was induced to feel more self-aware of the virtual or real self, with participants in the former category expected to report higher levels than participants in the latter.

Hypothesis 2a: Participants who are induced to feel self-aware of the virtual self (i.e., videotaped on the screen only) will report feeling more *presence* than participants who are induced to feel self-aware of the real self (i.e., videotaped on the screen and in the physical room).

Hypothesis 2b: Participants who are induced to feel self-aware of the virtual self (i.e., videotaped on the screen only) will report feeling more *self-presence* than participants who are induced to feel self-aware of the real self (i.e., videotaped on the screen and in the physical room).

3. Multitasking Performance as a Measure of Presence

The amount of presence or self-presence that an individual feels affects how such individuals perform on various tasks. For example, the level of similarity between avatar and participant in a virtual environment significantly affects self-presence and plays an important role in where participants move in a virtual environment, how close they stand to other avatars, and their willingness to commit embarrassing acts [9]. In the present study, level of presence and self-presence were expected to affect not only performance within the virtual environment but performance on multitasking tasks that occur in the real environment as well.

The use of such a measure is notable because of increasing evidence that media use is an activity that often occurs concurrently with other activities [11, 12, 13] and because of the dearth of media effects research that examines such multitasking. While multitasking with television and music has been shown to affect performance on homework-type and other cognitive activities [14, 15, 16, 17, 18, 19, 20], no empirical research seems to have been conducted on the effects of multitasking while using interactive media. According to a recent investigation of young people, multitasking while using video games is the most common form of multitasking while using interactive media (when computer use is segmented into activities such as homework, IM, email, websites, etc) [12]. The present study delves into this largely unexplored area of multitasking while using video games with the intent of contributing theory and methods that may be applicable to multitasking with other interactive media.

The present study is one of the first to concurrently utilize the constructs of presence and multitasking as a means of understanding both concepts. Presence and multitasking are naturally complementary areas of study because levels of presence are dependent on cognitive stimuli [5] and the chief attention-oriented explanations of the effects of multitasking largely focus on cognitive resources [14, 15, 21, 22, 23]. There are two prevalent, somewhat conflicting areas of attention-oriented explanations for changes in quality of performance while multitasking, and both of these explanations are applicable to the construct of presence. *Limited-capacity* theories posit that performance suffers when people attempt to utilize more mental resources than are available within their overall pool of such resources [19]. Applied to presence, self-presence and multitasking, limited capacity theories would imply that individuals have a finite supply of resources that can be allocated to feeling presence or self-presence, so when more of such resources are required to experience presence or self-presence in multiple (real or virtual) environments than are available, the feeling of presence or self-presence suffers in one or all of the environments. *Structural interference* theories posit that performance suffers when similar cognitive tasks compete for similar mental resources, not when resource capacity limits are reached [16, 22, 23]. Applied to presence, self-presence and multitasking, structural interference theories would imply that there are numerous types or causal mechanisms of presence and self-presence and that similar types or mechanisms of presence and self-presence cannot coexist within multiple (real or virtual) environments.

Both the limited-capacity and structural interference theories are addressed in the present study. Although increases in presence or self-presence may lead to higher levels of cognitive performance [1], such increases are not expected to augment mental capacity to an extent that would imply that higher presence or self-presence is associated with improved multitasking performance. Instead, presence and self-presence should be negatively related with multitasking performance. One possible explanation for such a relationship, consistent with limited capacity theories, is that increased feelings of presence and self-presence within the game environment will require an increasing proportion of total mental resources, reducing the amount of resources available for multitasking tasks, thereby impairing performance on these tasks. Another explanation, consistent with structural interference, is that performance on the multitasking tasks suffers when these tasks require similar resources to those that are being utilized to facilitate the feeling of presence or self-presence in the game.

In order to account for both of these explanations, various types of multitasking tasks were utilized in the present study, including memory encoding and retrieval of various types of information and brainteaser-type problem solving. Each of these tasks requires different amounts and types of cognitive load, but there were no specific expectations of whether limited-capacity or structural interference theories would explain the effects. Further, because the research on presence and self-presence is limited, no distinction is made between these constructs regarding the expected strength or type of effects. In other words, performance on any or all of the multitasking tasks was expected to suffer when there were high feelings of either presence or self-presence.

Hypothesis 3a: Participants who report feeling the most presence or self-presence will perform the worst on some or all of the multitasking tasks.

Because the measurement tools of presence and self-presence had potentially limited predictive power, the manipulations themselves were also used to test the effects on multitasking performance. Again, no distinction is made between these manipulations regarding the expected strength or type of effects.

Hypothesis 3b: Participants who use an avatar they have created in their own likeness or who are induced to feel self-aware of the virtual self (i.e., videotaped on the screen only) will perform worse on some or all of the multitasking tasks than participants who use a pre-made avatar that is assigned to them or who are induced to feel self-aware of the real self (i.e., videotaped on the screen and in the physical room).

To briefly recap, the present study examines the causal mechanisms and task-related effects of presence and self-presence with the aim of contributing to the understanding of how virtual[M1] should be designed and implemented. The two expected causal mechanisms of presence and self-presence are level of similarity between individuals and their avatars, and self-awareness of the real and virtual self. The manipulated feelings of presence and self-presence are expected to affect multitasking performance. Using the design described below, the present study tested the hypotheses related to these causal mechanisms and effects.

4. Method

4.1 Participants

32 females (8 in each condition) and 32 males (8 in each condition) participated in the study at a large, western American university, and spanned the ages of 18-30. Participants who were in the introductory communication class received course extra credit while other students received no compensation. Participants were randomly assigned to one of the four experimental conditions resulting from crossing the avatar similarity and self-awareness variables. Differences regarding compensation were balanced evenly across conditions.

4.2 Apparatus

The main device used in this study was the Nintendo Wii console, the latest generation in home entertainment systems created my Nintendo, and the game Wii Tennis. Due to the unique nature of its control interface, essentially a wireless controller with 5 degrees of freedom (pitch, yaw, roll, x-axis, z-axis), playing the Wii requires much more physical movement than playing with most other video game consoles. Because much of this physical movement is directly correlated with the avatar's movement on-screen, the Wii has the potential to induce significant amounts of presence within players. For example, when playing Wii tennis, the game used for this study, the player tosses up the ball to serve by moving her arm upwards and then swings her arm forward as if the controller were a racquet to hit the ball. These movements are quite similar to the movements required in real tennis and so the opportunity for a player to perceive this virtual experience as real is significant.

The Wii with Wii Tennis were also chosen as the primary device for this study because of the feature that allows players to design their own avatar, known as a "Mii", and then use this avatar in the game. Mii's can be customized in a variety of ways, including height, body mass, face shape, skin/eye/lip color, hairstyle and facial features. Given this vast range of options, Mii's can be created to look quite similar, though cartoonish, to their real-life counterparts.

Standard equipment also used in this study included a computer, 46-inch television, video camera, and stopwatch. The computer was used to administer the questionnaires to the participants. The output from the Wii was displayed on the television. The video camera, used to induce self-awareness but never actually turned on, was stationed in the back of the room. The stopwatch was used to administer the multitasking questions. The room in which the study was conducted and equipment used is depicted in Figure 1, including the Nintendo Wii (1), Wii controller (2), television with Mii customization screen displayed (3), and video camera (4).

Figure 1. Room and Equipment

4.3 Design

The design included two between-subjects variables: *avatar similarity* (similar or dissimilar) and *self-awareness* (virtual or real self). Gender was distributed evenly and participants were randomly assigned to one of the four conditions. The 2 x 2 matrix depicting these assignments can be found in Table 1.

	Self-Aware: Virtual Self	**Self-Aware: Real Self**
Avatar and Participant Similar	16 Participants	16 Participants
Avatar and Participant Dissimilar	16 Participants	16 Participants

Table 1. Study Conditions

In order to control for possible effects from the act of creating a Mii, all participants created a Mii in their own likeness. Participants in the similar-avatar condition played the game with the Mii they had created. Before beginning the games, these participants were told, "You will be playing with your Mii." Participants in the dissimilar avatar condition played the game with a generic-looking Mii that was assigned to them. In this latter condition, avatar gender always matched the participants' gender. Before beginning the games, these participants were told, "You will be playing with," for females, "Amanda" or "Stacie," and for males, "Larry" or "Bob". Participants in this condition were randomly assigned to one of two Miis. Images of these generic-looking Mii's can be found in Figure 2.

Figure 2. Generic-looking Miis

The researcher administered the self-awareness manipulation verbally by reciting a scripted statement that also reinforced the avatar similarity condition. Participants in the virtual self-aware condition were told that while they played the game, the video camera would record their performance on the screen only. Participants in the real self-aware condition were told that while they played the game, the video camera would record their performance on the screen as well as in the physical room. Reflecting the avatar similarity condition, for participants in the virtual self-aware and avatar similar condition, the researcher pointed to the video camera and said, "We have set up that camera right there," and then pointed at the screen and said, "to record *you* in the game." For participants in the real self-aware and avatar similar condition, the research pointed to the video camera and said, "We have set up that camera right there," then pointed to the participant and said, "to record both you," and then pointed to the screen and said, "and *your Mii* while you play the game." For participants in the virtual self-aware and avatar dissimilar condition, the researcher pointed to the video camera and said, "We have set up that camera right there," and then pointed at the screen and said, "to record *Amanda* in the game." Note that depending on participant gender and random selection the researcher could have also said "Stacie", "Bob", or "Larry". For participants in the real self-aware and avatar dissimilar condition, the research pointed to the video camera and said, "We have set up that camera right there," then pointed to the participant and said, "to record both you," and then pointed to the screen and said, "and *Amanda* while you play the game." Again, the specific name depends on participant's gender and random selection.

4.4 Procedure

After participants arrived at the laboratory and reviewed their informed consent information, they filled out a questionnaire that asked basic demographic information and then learned how to properly wear and manipulate the Wii controls. The researcher then instructed the participant to design a Mii and requested, “Please make this Mii look as much like yourself as possible.” After customizing their Mii for no more than 5 minutes, participants learned how to play Wii tennis. The researcher read instructions on how to serve, return and direct the ball and then demonstrated these functions while playing a few volleys with the computer. According to condition, participants were then told which Mii they would be playing with and the function of the video camera.

Next, participants were instructed to remember the following list of facts, words, and numbers. The research read this list slowly in the order presented below.

Facts
- A dime has 118 ridges around the edge.
- A cat has 32 muscles in each ear.
- A dragonfly has a life span of 24 hours.
- A goldfish has a memory span of three seconds.
- Cats sleep an average of 16 hours per day.

Words
- Cantankerous
- Interspersed
- Rejuvenate
- Mollify
- Trampoline

Numbers
- 690
- 695
- 130
- 214
- 340

Participants were then instructed to play a series of single-match games against the computer and to listen to and respond verbally to the researcher while they were playing. Starting from the participants’ first serve, at 30-second intervals the researcher asked the participant to remember (recognize) the information that had been read earlier. These questions were phrased in the format of, “Question, true or false, a cat has 42 muscles in each ear?” and “Question, yes or no, do you remember hearing the word ‘mollify’?” The stopwatch was paused in between tennis matches as well as while the participants responded to questions during the matches. After being asked to remember one fact, one word and one number, participants were told an additional fact in the format of, “New fact, there are about 1500 active volcanoes world-wide.” Following the next 30-second interval, participants were asked to pause and read a brainteaser-type word problem. Participants were given different time limits for different word problems, ranging from 30 to 90 seconds, depending on problem difficulty. This entire process – fact question, word question, number question, new fact presentation, and word problems – was repeated five times while the participant played tennis. All of the new facts and word problems, with time limits, are listed below:

New Facts
- There are about 1500 active volcanoes worldwide.
- The winter of 1932 was so cold that Niagara Falls froze completely solid.
- A snail can sleep for three years.
- There are 293 ways to make change for a dollar.
- February 1865 is the only month in recorded history not to have a full moon

Word Problems
- How can you throw a ball as hard as you can and have it come back to you, even if it doesn't hit anything, there is nothing attached to it, and no one else catches or throws it? (30 secs to respond)
- The day before yesterday I was 25 and next year I will be 28. (This is true only one day in a year.) When was I born? (60 secs to respond)
- How many flowers do I have if all of them are roses except two, all of them are tulips except two, and all of them are daisies except two? (30 secs to respond)
- If you had ONLY a 5-litre and a 3-litre bowl and unlimited access to water. How would you measure exactly 4 litres (to be contained in one or both of the bowls)? (90 secs to respond)
- I am looking at somebody's photo. Who is it I am looking at, if I don't have any brothers or sisters and the father of that man on the photo is the son of my father? (45 secs to respond)

After this process had been iterated 5 times, the participants were told to stop playing and were asked some additional questions about specific characteristics of the game and about the new facts they were told while playing. The former included the three questions, “Did your Mii have legs while you were playing?”, “Did your Mii have arms while you were playing?”, and “What did the sign in the back of the tennis court say?” The latter were quite similar to the fact questions asked during the game and so they are not listed below. The participants then completed a post-questionnaire that measured their feelings presence and self-presence, their video gaming and multitasking habits, and their qualitative attitudes about their Mii and the self-awareness condition. The items from this questionnaire that were used in the analysis are described in the following section. Finally, before leaving the room, the participants were debriefed about the purpose of the study and the minor deception utilized.

5. Measures

Reliability analysis was used to create a subjective measure of presence that included eight questions to which the participants responded on 5-pt likert scales. In these questions the participant indicated the extent of agreement with the statements, “The game looked realistic,” “I felt like I was in the tennis game,” “The game felt realistic,” “I felt engaged in the game,” “I felt bored while playing the game” (reverse coded), “I gripped the controls tightly while playing,” “I used grand arm movements while playing,” and “I swung the controller like it was a real racket.” Cronbach’s alpha for this composite measure was .802.

Reliability analysis was also used to create a subjective measure of self-presence that included five questions to which the participants responded on 5-pt likert scales. In these questions the participant indicated the extent of agreement with the statements, “I liked the Mii I played with,” “I felt connected to the Mii I played with,” “The Mii I played with was an accurate representation of me,” “The Mii I played with looked like a type of person I would want to be,” and “The Mii I played with looked like me.” Cronbach’s alpha for this composite measure was .791.

As described above, multitasking performance included measures of the number of facts, words and numbers the participants remembered correctly and the number of word problems the participants answered correctly. There was not enough agreement between any of these items to create a composite measure of multitasking performance.

6. Results

An analysis of variance was used to test the effects of Mii similarity on self-presence and presence, with the between-subjects Mii similarity manipulation as the independent variable and the subjective composite measures of self-presence and presence as the dependent variables. Supporting Hypothesis 1a, there was a significant main effect for Mii similarity and *self-presence*, F (1, 62) = 13.56, $p < 0.01$, $\eta_p^2 = 0.19$, with participants who used a similar Mii reporting more self-presence (mean = 15.77, SD = 3.66) than participants who used a dissimilar Mii (mean = 12.22, SD = 3.77). There was no main effect for Mii similarity and *presence*, F (1, 62) = 0.00, $p = 0.96$, $\eta_p^2 = 0.00$, so Hypothesis 1b was not supported.

An analysis of variance was used to test the effects of self-awareness on presence and self-presence, with the between-subjects self-awareness manipulation as the independent variable and the subjective composite measures of presence and self-presence as the dependent variables. Supporting Hypothesis 2a, there was a significant main effect for self-awareness and *presence*, F (1, 62) = 4.28, $p < .05$, $\eta_p^2 = 0.07$, with participants induced to feel self-aware in the virtual environment reporting more presence (mean = 29.78, SD = 4.51) than participants induced to feel self-aware in the real environment (mean = 26.83, SD = 6.70). There was no main effect for self-awareness and *self-presence*, F (1, 64) = 0.47, $p = .50$, $\eta^2 = 0.01$, so Hypothesis 2b was not supported.

Interaction effects between the independent variables and the presence and self-presence dependent variables were also tested. There was no interaction effect for Mii similarity by self-awareness with *presence* as the dependent variable, F (1, 62) = 1.92, $p = 0.17$, $\eta_p^2 = 0.03$, nor for Mii similarity by self-awareness with *self-presence* as the dependent variable, F (1, 62) = 0.03, $p = 0.87$, $\eta_p^2 = 0.00$.

None of the simple correlations between the composite measures of presence and self-presence were significantly related to multitasking performance. Hence, Hypothesis 3a was not supported at all. The insignificant correlation results can be found in Table 2 below.

	In-Game Fact Memory
Presence	Pearson's Correlation = -.12, p = .36
Self-Presence	Pearson's Correlation = -.14, p = .30
	In-Game Word Memory
Presence	Pearson's Correlation = .10, p = .45
Self-Presence	Pearson's Correlation = -.25, p = .06
	In-Game Number Memory
Presence	Pearson's Correlation = .05, p = .72
Self-Presence	Pearson's Correlation = -.17, p = .21
	Word Problem Performance
Presence	Pearson's Correlation = -.18, p = .17
Self-Presence	Pearson's Correlation = -.05, p = .70
	Memory of Game Characteristics
Presence	Pearson's Correlation = -.03, p = .84
Self-Presence	Pearson's Correlation = .20, p = .17
	Post-Game Fact Memory
Presence	Pearson's Correlation = -.06, p = .63
Self-Presence	Pearson's Correlation = -.15, p = .26

Table 2. Insignificant Multitasking Correlation Results

An analysis of variance was used to test the effects of the Mii similarity and self-awareness manipulations on the multitasking performance dependent variables. Regarding performance on the word problems, partially supporting Hypothesis 3b, there was a significant main effect[1] for self-awareness, F (1, 62) = 4.1, $p < .05$, $\eta_p^2 = 0.07$, with participants induced to feel self-aware in the real environment answering more word problems correctly (mean = 1.69, SD = 1.23) than participants induced to feel self-aware in the virtual

[1] Gender was used as a covariate there was a weak main effect between gender and word problem performance, F (1, 62) = 3.9, $p = .05$, $\eta^2 = 0.06$, with males answering more word problems correctly (mean = 1.69, SD = 1.26) than females (mean = 1.13, SD = 1.00).

environment (mean = 1.13, SD = 1.04). There was no main effect for Mii similarity, F (1, 62) = 0.20, p = .65, $\eta_p^2 = 0.00$, and no interaction effect for Mii similarity by self-awareness, F (1, 62) = 0.82, p = 0.18, $\eta_p^2 = 0.03$.

Using an analysis of variance, the effects on multitasking performance were also tested with the two independent variables (Mii similarity and self-awareness) and the dependent variable that reflects the participants' ability to remember (encode) a series of new facts while playing the game and recognize these new facts after playing. There were no main effects for self-awareness, F (1, 62) = 0.45, p = .47, $\eta_p^2 = 0.01$, or for Mii similarity, F (1, 62) = 1.41, p = .24, $\eta_p^2 = 0.02$. Partially further supporting Hypothesis 3b, there was a significant interaction effect for Mii similarity by self-awareness, (1, 62) = 4.33, p < .05, $\eta_p^2 = 0.07$, and the means and confidence intervals of performance by condition for this effect are illustrated in Figure 3.

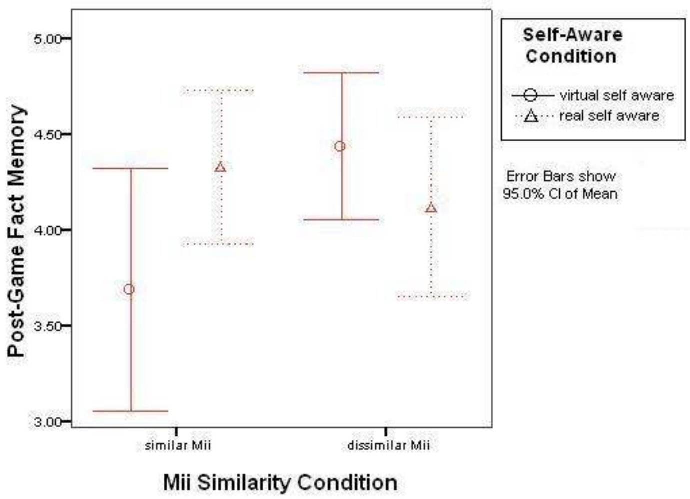

Figure 3. Post-Game Fact Memory

Using an analysis of variance, the effects on multitasking performance were also tested with the two independent variables (Mii similarity and self-awareness) and the dependent variable that reflects the participants' ability to remember a list of numbers before playing the game and recognize (retrieve) these numbers while playing. There were no main effects for self-awareness, F (1, 62) = 0.28, p = .60, $\eta_p^2 = 0.01$ or for Mii similarity for males, F (1, 62) = 2.53, p = .12, $\eta_p^2 = 0.04$. There was no interaction effect for Mii similarity by self-awareness, F (1, 62) = 0.91, p = .34, $\eta_p^2 = 0.02$. However, splitting the data according to gender and rerunning the test did yield one significant result with regard to number recognition, albeit unreliable because of the low N. Partially supporting Hypothesis 3b, for females only, there was a significant interaction effect for Mii similarity by self-awareness, F (1, 30) = 6.18, p = .02, $\eta_p^2 = 0.18$. The means and confidence intervals of performance by condition for this effect are illustrated in Figure 4.

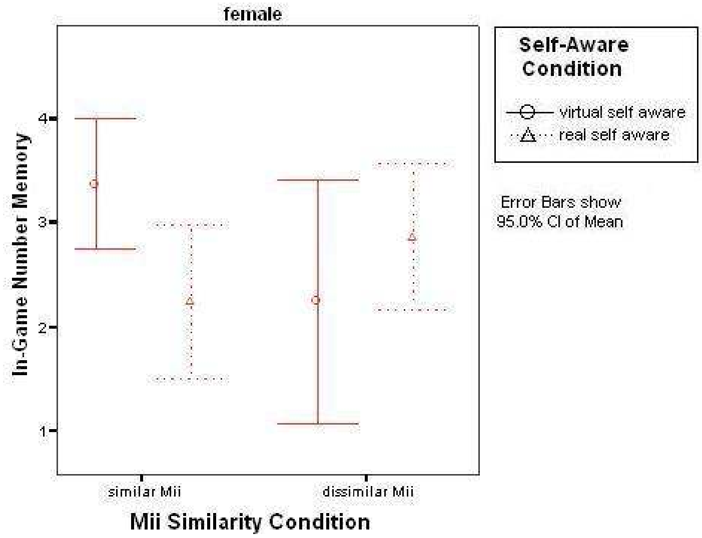

Figure 4. Female In-Game Number Memory

None of the other multitasking effects tested with an analysis of variance provided significant results.

7. Discussion

The findings outlined above provide some evidence for the basic premise of this study. Namely, feelings of presence and self-presence can be manipulated and such manipulations can affect performance on multitasking tasks. A detailed explanation of these findings follows.

7.1 Manipulating Presence and Self-Presence

The expectation that feelings of presence and self-presence are dependent on whether participants are assigned to a character that is similar or dissimilar to themselves was partially fulfilled. Participants who used a Mii that was dissimilar to themselves reported significantly less *self-presence* than participants who used a Mii that was similar to themselves. However, feelings of *presence* were unaffected by character assignment. Hence, Hypothesis 1a was supported but Hypothesis 1b was not. The latter finding is not surprising. Presence is an umbrella concept to which self-presence belongs in addition to other factors. This finding indicates that the other factors that affect presence most likely influence presence more significantly than self-presence. However, such a conclusion based on a lack of significant results is not dependable. Instead, it is fair to conclude that these results do not contradict this potential explanation.

The former result, that avatar assignment and self-presence are significantly related, corroborates previous research and notably implies that level of self-presence can be manipulated through avatar assignment. Further, in their open-ended responses, many participants in the dissimilar Mii condition noted a lack of connectedness to the Mii based on this dissimilarity, for example, by stating, "Because I didn't use the one I made, I didn't feel any sense of connection to the one I played with." However, some participants in the opposite condition indicated that the Mii's similarity to themselves did not affect their performance, for example, by stating, "After I created the Mii character I did not pay much attention to his looks. I was simply focused on winning the matches and answering the question correctly." Hence, the effects of Mii similarity on self-presence sometimes goes unnoticed by the user, implying that choosing an avatar in order to induce an appropriate level of self-presence, depending on environmental constraints, should not always be left up to the user. Future research should empirically examine whether users understand the relationship between avatar similarity and self-presence and how systems should assign avatars in either case.

The expectation that feelings of presence and self-presence are dependent on whether participants are induced to feel self-aware of the virtual self (i.e., videotaped on the screen only) or of the real self (i.e., videotaped on the screen and in the physical room) was partially fulfilled. Participants who were induced to feel self-aware of the virtual self reported significantly less *presence* than participants who were induced to feel self-aware of the real self. However, feelings of *self-presence* were unaffected by the self-awareness inducement. Hence, Hypothesis 2a was supported but Hypothesis 2b was not. The latter finding is not surprising because the inducement of self-awareness focuses on the salient environment, not on representation of the self. The former implies that level of presence can be manipulated by inducing self-awareness within real or virtual environments, but it should be noted that the effect size is relatively small (.07).

As with the previous finding, the effects of videotaping went unnoticed by many participants, indicated by statements such as, "I was initially uncomfortable wondering where the video of me playing might end up being played (in case I [stunk]!) but forgot its presence pretty quickly." Self-awareness can be manipulated through many other mechanisms besides videotaping and could be an important facet of developing media technologies that adapt to fluid environmental constraints. Future research should test the effects of such additional mechanisms of inducing self-awareness, such as by referring to facets of the real or virtual environments.

7.2 Multitasking Performance

The expectation that multitasking performance is dependent on the feelings or manipulations of presence and self-presence was partially fulfilled. There were no significant differences in multitasking performance between participants who reported feeling the most presence or self-presence and participants who reported feeling the least presence or self-presence. So, Hypothesis 3a was unsupported. The manipulations of presence and self-presence did significantly affect performance on some of the multitasking tasks, so Hypothesis 3b was partially supported.

The lack of a relationship between multitasking performance and feelings of presence or self-presence could partially be explained by flaws in these composite measures that prevent them from fully representing the concepts they attempt to target. Further, these measures are based on self-report items, the reliability of which as a measurement of presence and self-presence is questionable. An alternative explanation may be rooted in the lack of validity of these concepts themselves. As noted in the beginning of this paper, the definitions and operationalizations of presence and self-presence are still hotly debated. As the findings indicate, the definitions of presence and self-presence utilized for this study may not have been consistent with the multitasking component of the inquiry. Yet, it is still notable that the manipulated independent variables caused differences in these measures of presence and self-presence and also caused differences in multitasking performance. While it is possible that the latter changes occurred due to some other mechanisms besides presence or self-presence, such a mechanism would most likely be closely tied to these concepts. So although the measures of presence and self-presence were not related to multitasking performance, because the manipulations that affected presence and self-presence also affected multitasking behavior, the potential applications of this study regarding the design of virtual environments is not hindered. Future research may find that concepts closely related to presence and self-presence affect multitasking performance, or alternatively, the definition of presence and self-presence may adapt in ways that allow for these concepts to measurably affect multitasking performance.

Participants who were induced to feel self-aware of their virtual self (i.e., videotaped on the screen only) performed worse on the word problem task than participants who were induced to feel self-aware of their real self (i.e., videotaped on the screen and in the physical room). This finding is consistent with the notion that more cognitive resources are allocated to the environment in which individuals feel more present. The small effect size (.07) should be noted and it should be emphasized that the word problem task is not entirely a multitasking task because participants paused the game while they completed this task. Hence, it seems that when participants are induced to feel self-aware in the physical room, they are more willing to break their feeling of presence in the virtual world in order to complete the task. Otherwise, they are more anxious to return to the virtual world and hence dedicate fewer cognitive resources to the task. In order to test this explanation, future research should examine the differences between performance on various multitasking tasks that occur while the game is either paused or continuous.

Contributing further mixed support for Hypothesis 3b are the interaction effects found for remembering a series of facts and a series of numbers while playing. Participants who played with a similar Mii remembered more facts when induced to feel self-aware of their real self than when induced to feel self-aware of their virtual self, but participants who played with a dissimilar Mii remembered more facts when induced to feel self-aware of their virtual self than when induced to feel self-aware of their real self.

Further, regarding remembering numbers, it appears that female participants who played with a similar Mii recognize more numbers when induced to feel self-aware of their virtual self than when induced to feel self-aware of their real self, but female participants who played with a dissimilar Mii recognize more numbers when induced to feel self-aware of their real self than when induced to feel self-aware of their virtual self. This latter finding is tenuous because of the low number of female participants in each condition (eight), but is still interesting to speculate about, especially because the effect is in the opposite direction of the previous finding. The effect regarding number recognition is consistent with Hypothesis 3b within the dissimilar Mii condition and the effect regarding remembering new facts is consistent with Hypothesis 3b within the similar Mii condition. Namely, in these conditions, inducing self-awareness of the real self improves multitasking performance. Yet, is not immediately apparent why inducing self-awareness of the real self detracts from multitasking performance in the opposite Mii similarity conditions. Future research should reexamine the relationship between Mii similarity and multitasking performance to see if this curious interaction effect persists.

The opposite direction of the findings between the fact encoding and number recognition tasks is also curious and may relate to the different cognitive mechanisms required by the two tasks. The number task requires multitasking between the game and memory retrieval of the numbers. The facts task requires multitasking between the game and the memory encoding of facts for retrieval after the game. It is possible that encoding and retrieval utilize different types or methods of acquiring cognitive resources and that these differences are magnified by the feeling of presence or self-presence. Although no specific hypothesis was constructed with regard to such interaction effects, these findings do lend support to a structural interference explanation of multitasking effects because it seems that different types of activities with similar levels of cognitive load affect multitasking in different ways. This claim is further supported by the findings that only some of the multitasking measures were related to the independent variables. Future research should examine how various types of cognitive mechanisms are affected by feelings of presence and self-presence while multitasking.

7.3 Shortcomings

Although the present study provides some notable findings regarding presence, self-presence and multitasking, there are some important shortcomings in this study's design. First, the inducement of self-awareness relied on participants' believing that they were being videotaped. Videotaping can cause a variety of effects in addition to self-awareness, and it is possible that these other effects contributed to the participants' multitasking performance and feelings of presence and self-presence. Unfortunately, this study did not include a manipulation check to ensure that the video camera's focus on the screen or on the screen and physical room induced self-awareness to a greater extent than other psychological mechanisms that could have affected the results. Future research should include such manipulation checks and as suggested earlier, should use different methods of inducing self-awareness and reinforcing virtual or real identities.

An additional issue with the study design is that playing with a similar Mii is confounded with playing with a Mii that the participant built. Conversely, participants who played with a dissimilar Mii were disallowed from playing with the Mii that they built. This may be a problem if playing with something one has built vs. something one has not built is a more significant manipulation than playing with a character that is similar vs. dissimilar to oneself. For example, the participants who played with the generic Mii may have been disappointed or frustrated that they could not play with the Mii that they built. Future research should include a condition in which some participants play with an avatar that they built to be dissimilar from themselves and a condition in which some participants play with an avatar that they did not build that is similar to themselves, in addition to the same conditions from this study.

Another flaw in this study relates to the participants' skill levels. Namely, not all of the participants began the study at the same gaming or multitasking skill levels and this was not controlled for in the data analysis. Instead, it was assumed that such differences would be negligible because the participants were randomly assigned to condition. However, the number of participants may not have been large enough to dampen potential effects. Further, the variance in gaming skill level was likely too large to randomize out because of the lack of availability of the Nintendo Wii at the time the study was conducted. Therefore, it is possible that participants who were already highly skilled before participating had an easier time playing the game, allowing more resource allocation for the secondary tasks. Future studies should exclude participants with extreme gaming skill levels and should test and control for extreme multitasking or cognitive abilities.

A final design flaw of this study is that participants who did not play with the Mii they built were randomly assigned to one of two generic-looking Miis, and although these Miis were typical game characters, there may have been something specific about their appearance or names that affected participants' performance. A better design would have had participants in this condition play with the Miis that participants in the opposite Mii similarity condition had previously built and used. This way all of the same Miis would have been used in both conditions, ensuring that there were no effects from the specific way that these Miis looked.

Conclusions

The novel study described here concurrently examines the concepts of presence, self-presence and multitasking, and illustrates that such examinations are a potentially promising avenue of research. The findings that presence and self-presence can be manipulated by inducing self-awareness of the virtual or real self, or by avatar assignment, respectively, corroborates previous research and presents these concepts as valuable indicators of technology users' psychological states. The finding that these same manipulations can affect performance on particular multitasking tasks provides support for the structural interference explanation of multitasking effects and indicates that such manipulations might be strategically used to inform the design of virtual environments.

Yet, while the same manipulations affect feelings of presence and self-presence and affect multitasking performance, no relationship was found between multitasking performance and the feelings of presence or self-presence. Hence, the study has not provided a link between the psychological states in question and the participants' behaviors. This implies that either the measures of presence and self-presence are flawed or that there is some additional factor that is affecting the relationship between the manipulations and multitasking that is closely related to presence or self-presence. The fundamental conclusion then is that more research must be conducted in order to develop the conceptual definitions of presence and self-presence in ways that facilitate better operational measures of these concepts.

Although this study should not serve as an archetype for research on presence, self-presence, and multitasking, namely because of the small effect sizes, shortcomings in design, and somewhat unintuitive results, it instead should be considered a pioneering attempt at understanding how these concepts interrelate and what future research should be conducted. Further, this study provides a basis for speculation about the potential benefits of such research. If this future research corroborates the findings that avatar assignment and self-awareness affect feelings of presence and self-presence, thereby impacting the quality of multitasking performance, media technology applications could be built that incorporate such findings in order to maximize efficiency, safety and enjoyment.

Returning to the opening example from this paper in which you are giving directions over the phone while playing a video game, imagine that the phone and game could work in concert to manage your feeling of presence within both mediated environments by manipulating which environment feels more salient to you or by changing some facet of how your character is represented. Imagine more serious multitasking scenarios: a pilot uses numerous virtual interfaces to monitor the performance of a space shuttle, a doctor performs multiple telesurgeries concurrently, or a teenager completes homework assignments in a virtual world while watching over a younger sibling. While the present study only provides a small step toward a contribution of design principles for such technologies, it is an early step upon which many others will hopefully tread.

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