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Virtual Experiences, Physical Behaviors: The Effect of Presence on Imitation of an Eating Avatar

Abstract

In this study, the role of presence in the imitation of a virtual model was examined. Immersive virtual environment technology (IVET) was used to create photorealistic virtual representations of the self that were depicted eating food in a virtual world. Changes in the virtual environment (via a changing or unchanging body) were incorporated to create variance in perceived subjective presence. Based on previous research, presence was hypothesized to affect the relationship between the environmental manipulations and the behavioral outcome of imitating the avatar's eating behavior. Here we show that presence did indeed affect imitation, but that the effects varied for men and women in accordance with previous research on sex differences in eating behavior. Men who experienced high presence were more likely than low presence men to imitate the virtual model and eat candy, whereas women who experienced high presence were more likely than low presence women to suppress the behavior and not eat candy.

1 Introduction

Virtual worlds are typically designed to elicit synchronous reactions while participants are in the virtual environment. For example, an approach or attack by a character in a video game may elicit an immediate psychological, physiological, and behavioral response by a player. Recent research, however, has revealed that experiences in virtual worlds also have the power to influence behaviors in the physical world after exposure (Anderson & Bushman, 2001; Fox & Bailenson, 2009; Price & Anderson, 2007; Rizzo & Kim, 2005; Yee, Bailenson, & Ducheneaut, 2009).

The progress of technology has allowed immersive virtual environments to become increasingly realistic. These advances may increase *presence*, the user's feelings that the virtual environment is real and that the user's sensations and actions are responsive to the virtual world as opposed to the real, physical one (Biocca, Harms, & Burgoon, 2003; Lee, 2004; Lombard & Ditton, 1997; Loomis, 1992; Slater & Steed, 2000; Steuer, 1992; Witmer & Singer, 1998). The experience of presence may be a result of characteristics of the technology used (IJsselsteijn, de Ridder, Freeman, Avons, & Bouwhuis, 2001), aspects of the environment such as graphic realism (Ivory & Kalyanaraman, 2007), or

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individual differences among users (Garau, Slater, Pertaub, & Razzaque, 2005). The examination of presence is important, as previous studies have shown that the subjective experience of presence can impact the effectiveness of virtual treatments (Krijn et al., 2004; Villani, Riva, & Riva, 2007) and how well these treatments translate into real world behavior (Price & Anderson, 2007).

Research has determined several variables that influence a user's experience of presence, including features of the virtual environment, characteristics of the user, and the task in which the participant is engaged (Rand et al., 2005). For example, changes in the virtual environment can cause users to become more engaged. The environment is said to have a high level of interactivity to the extent that these changes are contingent upon the user's actions (Steuer, 1992). Early theories hypothesized that interactivity would be a contributing factor to the experience of presence (Lombard & Ditton, 1997), and subsequent empirical work has demonstrated this in the laboratory. Li, Daugherty, and Biocca (2002) and Fortin and Dholakia (2005) found that participants exposed to interactive advertisements reported greater presence than those exposed to noninteractive ones. Skalski and Tamborini (2007) found that participants reported greater social presence after experiencing an interactive agent rather than a noninteractive one. These changes in the environment may help focus participants' attention and keep them more engaged, resulting in greater presence.

Regardless of the objective features of virtual worlds, the user's psychological, subjective experience of presence may enhance the experience and effects of a virtual environment both during immersion and subsequently in the real world. Thus, researchers may expect that users who experience high levels of presence in a particular environment may have a distinctly different experience—and demonstrate different effects—than users who experience low levels. Presence has been shown to be an important factor in determining the behavioral outcomes of virtual treatments in several realms. Lombard and Ditton (1997) note the crucial role presence plays in learning through different stimuli. Villani et al. (2007) administered relaxation therapy treatments to patients with anxiety disorders and found that presence mediated the relationship between the mode of presentation and the efficacy of the treatment. In the advertising realm, Fortin and Dholakia (2005) found that presence mediated the relationship between the interactive nature of an advertisement and its effectiveness.

Although research has spanned the realms of advertising, therapy, and learning, research has not yet addressed the role of presence in assessing the effectiveness of *virtual imitation*. It is possible that enhanced feelings of presence may encourage users to perform an avatar's modeled behavior. In the current study, we leverage these previous findings about interactivity (using a model whose body changed or did not change) to create variance in the user's sense of presence while observing a modeled eating behavior. In other words, the purpose of this study was not to examine factors that cause subjective presence; indeed, hundreds of studies have already shed light on this relationship (see Lee, 2004, for a review of this previous work). Instead, the current study examined how the subjective experience of presence affects whether or not behavioral transfer occurs from a virtual setting to the real world. We manipulated objective features of the virtual world in order to create variance in the user's subjective experience of presence. As a result, we can examine whether presence can influence the user's modeling of the demonstrated behavior.

2 Virtual Imitation

According to Bandura's social cognitive theory (1977, 2001), people often imitate behaviors they observe being performed by others. Bandura's initial studies featured video recordings of different adult models beating a Bobo doll. Bandura showed these videos to children under different conditions and then observed how frequently they would imitate the demonstrated aggressive behavior. Several factors, including the similarity of the model to the child, the child's perceived ability to imitate the behavior, and the rewards and punishments associated with the adult's behavior, predicted the likelihood of the child performing the modeled action and beating the Bobo doll.

New media technologies enable us to examine the power of models and imitation in ways that were not previously possible through novel manipulations of different social cognitive constructs. First, immersive virtual environment technology (IVET) allows researchers to use an individual's photographs to create digital representations of humans that look like the self (Bailenson, Beall, Blascovich, & Rex, 2004). According to Bandura (1977, 2001), optimizing the similarity of the model maximizes feelings of *identification* and promotes imitation. These virtual representations of the self (Bailenson, Blascovich, & Guadagno, 2008) can then be used to portray certain behaviors.

Previous work has implemented the self-model and examined the role of virtual identification. Fox and Bailenson (2009) found that exposure to an exercising self-model in a virtual environment, as opposed to an exercising other-model or a loitering self-model, led to subsequent exercise in the real world. Although this study demonstrated that an interactive self-model can be used to instigate physical behavior, the role of presence was not examined. Thus, it is important to determine the role presence may play in virtual modeling scenarios.

3 Overview of Experiment and Hypothesis

We designed an experiment to examine the effect of experiencing the virtual self eating on subsequent physical eating behavior. Participants were exposed to a stimulus in which they observed the virtual self eating. To externally manipulate factors contributing to presence, their virtual bodies either changed or did not change in accordance with the modeled behavior. (In this experiment, perspective was also manipulated in that participants saw the treatment from either a first or third person perspective. No differences were found between the two on any of the dependent variables, and thus perspective is not discussed further.) The internal, subjective experience of presence was assessed with a memory task that took place in the virtual environment as well as questionnaire items immediately following the treatment. While completing the questionnaire, participants were seated at a computer with a bowl of chocolates and given the opportunity to eat candy.

Presence has been shown to bolster the likelihood of the transfer of virtual experiences to real world behaviors. Thus, it is hypothesized that those who experience high levels of psychological presence will demonstrate more imitative eating behavior than those who experience low levels of presence.

4 Method

4.1 Sample

A sample was recruited from the student body of a medium-sized West Coast university. Participants received course credit or $20 for their participation. Four participants were dropped from the initial sample ($N = 73$) due to technical failure during the experiment or because they reported feeling ill that day. The final sample ($N = 69$) consisted of 32 men and 37 women who ranged in age from 18 to 29 ($M = 20.20$, $SD = 1.55$).

4.2 Design

A between-subjects design was employed. Participants were randomly assigned to one of two conditions: change ($n = 32$) or no change ($n = 37$).

4.3 Apparatus

Participants were placed in a fully immersive virtual environment. They donned a head mounted display (HMD) through which they were able to view the stimulus. The HMD was an nVisor SX with dual 1,280 horizontal by 1,024 vertical pixel resolution panels. The display presented a visual field subtending approximately 50° horizontally by 38° vertically. Stereoscopic images were rendered by a 1,900 MHz Pentium computer with an NVIDIA GeForce 6600 graphics card and were updated at an average frame rate of 60 Hz. Sensing equipment tracked users' motions (e.g., turning their heads) so that a realistic visual depiction of the environment could be updated constantly based on their movements. Participants' head movements were tracked by a three-

axis orientation sensing system (Intersense IS250 with an update rate of 150 Hz) and used to continuously update the simulated viewpoint. The system latency, or delay between the participant's movement and the resulting update in the HMD, was no greater than 80 ms. Vizard 3.0 software was used to assimilate tracking and rendering.

4.4 Procedure

At the beginning of the quarter, participants had their photographs taken with a digital camera for a presumably unrelated study. Approximately one month after the photo session, participants were solicited for the current study. Thus, all participants, regardless of condition, participated in the photo session and had their virtual head models constructed.

When participants entered the lab, they were instructed as follows:

> While inside the virtual world, you are going to observe your virtual self. Your virtual self will be presented with food and commence eating.
>
> In the changing conditions, participants were also told:
>
> You will then see yourself experience the consequences of dietary choices: if your avatar makes healthy decisions, it will lose weight. If your avatar makes unhealthy decisions, your avatar will gain weight.
>
> All participants were also told:
>
> As your avatar eats, you will also be engaging in a memory task. A sequence of numbers will appear. Your goal is to remember as many of those numbers as possible. After the sequence is finished, you'll be asked to recall those numbers.

Participants were seated at a table and outfitted in the HMD. In the virtual world, participants saw themselves positioned between two bowls, one full of carrots and one full of candy. Both bowls were labeled, and a package of each item was positioned near the bowl (a bag of carrots and a package of Reese's Cups). The experimenter pressed a key to commence the eating behavior. A computer algorithm randomly determined whether the avatar would eat carrots or candy first. After 3 min, the eating animation would stop and the avatar would then begin to eat the other food for 3 min. In the changing body conditions, the avatar lost weight when it ate carrots and gained weight when it ate candy. In the unchanging body conditions, the avatar did not appear to lose or gain weight while eating. See Figure 1 for an illustration of the changing body condition.

After exposure, participants were led to a computer and asked to complete the survey items. A bowl of chocolate candy (Hershey's Kisses and Rolos instead of the Reese's Cups featured in the stimulus) was placed next to the computer and participants were told they could help themselves if they wished. To ensure that participants did not feel as if they were being observed, the experimenter made an excuse to step outside the room and told participants to retrieve him or her when the survey was completed.

4.5 Measurement

4.5.1 Numbers Identified: Presence Proxy. Participants were presented with 10 sets of numbers and asked which of the numbers they recalled seeing while in the virtual world. The total of the numbers identified ranged from 5 to 10 ($M = 8.59$; $SD = 1.33$). The purpose of the distracter task, employed in previous IVET studies (Bailenson, Blascovich, Beall, & Loomis, 2003), was to keep the participant visually attended to the virtual human as well as to mask the experimental manipulation. This task also serves as a more objective measure of presence than subjective questionnaire items, which have been criticized for their validity (Slater, 2004). Because of the nature of cognitive overload, the more accurate participants' memory is for the numbers, the less attention they were paying to the stimulus and the virtual environment. In this sense, memory should be a proxy for presence.

4.5.2 Self-Reported Presence. A subjective measure of presence was also used. Ten items were used to assess participants' experience of presence while immersed in the virtual world. These items were culled from several sources (Bailenson & Yee, 2007; Nowak &

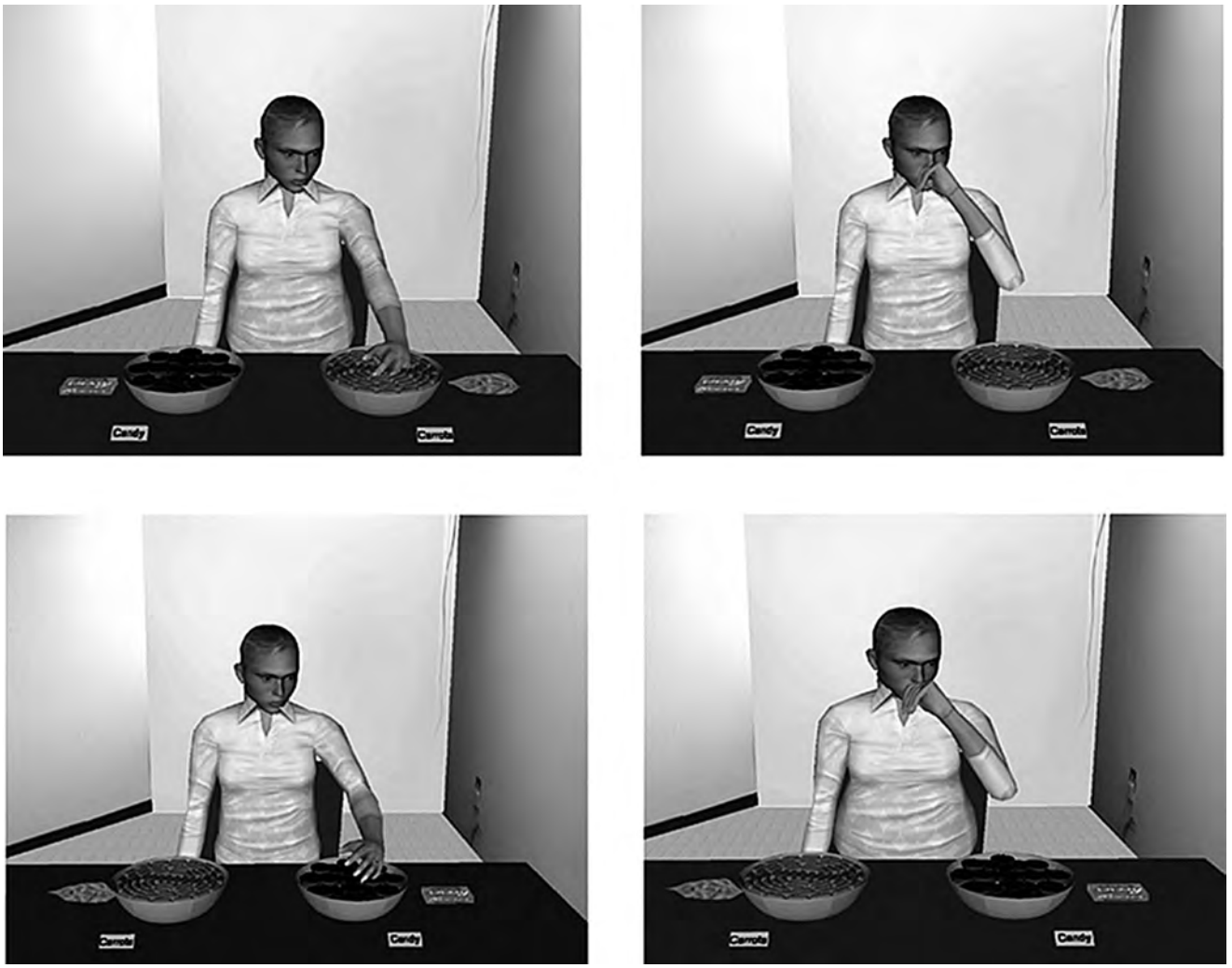

Figure 1. *Top row: as the female avatar eats carrots (left), it becomes slimmer (right). Bottom row: as the avatar eats candy (left), it becomes heavier (right).*

Biocca, 2003; Witmer & Singer, 1998). Participants indicated on a five-point scale (1 = not at all; 5 = extremely) the degree to which they felt present. Because the items were derived from multiple sources, a factor analysis was conducted; the results indicated that there was only one factor, and thus all items were combined to create the scale. Responses were averaged; scores ranged from 1.20 to 4.20 ($M = 2.52$; $SD = 0.64$). A Cronbach's alpha of $\alpha = .88$ was achieved. Scale items are listed in Appendix A.

4.5.3 Number of Candies Eaten. The experimenter counted the number of candies remaining in the bowl after the participant left to determine how many were eaten. Participants ate between zero and eight candies ($M = 1.30$; $SD = 2.28$).

4.5.4 Open-Ended Response. Participants were asked to respond to the following prompt: "Please describe any reactions you have to seeing this representation of yourself. How did it make you feel?"

5 Results

Because of previously identified sex differences in terms of presence (Nowak, Krcmar, & Farrar, 2008), as well as eating attitudes, norms, and behaviors (Baker, Little, & Brownell, 2003; Rosen, Silberg, & Gross, 1988), sex was entered as a factor in the analyses. Thus, 2 by 2 ANOVAs were run for the manipulation checks as well as the hypothesis test. All assumptions for the ANOVA were met for reported tests unless otherwise noted.

5.1 Manipulation Checks

For memory, there was a main effect of change, $F(1, 65) = 6.07$, $p < .05$, partial $\eta^2 = .09$. Participants in changing body conditions ($M = 8.16$; $SD = 1.61$) identified significantly fewer numbers than those in unchanging body conditions ($M = 8.97$; $SD = 0.90$). Neither the main effect for sex, $F(1, 65) = .14$, $p > .05$, partial $\eta^2 = .00$, or the interaction effect, $F(1, 65) = .28$, $p > .05$, partial $\eta^2 = .00$, were significant.

For self-reported presence, the main effect for change was significant, $F(1, 65) = 4.83$, $p < .05$, partial $\eta^2 = .07$. Participants in the changing body condition ($M = 2.68$, $SD = 0.56$) reported more presence than those in the unchanging body condition ($M = 2.38$, $SD = 0.68$). The main effect for sex also bordered on significance, $F(1, 65) = 3.53$, $p = .07$, partial $\eta^2 = .05$. In line with the findings of Nowak et al. (2008), there was a trend for men ($M = 2.65$, $SD = 0.71$) to self-report more presence than women ($M = 2.41$, $SD = 0.55$). The interaction effect was not significant, $F(1, 65) = 1.44$, $p > .05$, partial $\eta^2 = .02$.

5.2 Hypothesis

In order to examine the role of self-reported presence on modeling the eating behavior, we performed a median split to separate participants into low and high presence groups. Those scoring at or below the median ($M = 2.40$) were categorized as low presence ($n = 34$), whereas those scoring above the median ($n = 35$) were categorized as high presence. Sex was retained as a variable in the analyses.

To confirm that the median split of subjective responses continued to correspond to memory differences, a 2 by 2 ANOVA revealed a main effect for self-reported presence on number identification, $F(1, 65) = 5.27$, $p < .05$, partial $\eta^2 = .08$. Those in the low presence group ($M = 8.94$, $SD = 0.95$) identified more numbers than those in the high presence group ($M = 8.26$, $SD = 1.56$).

An examination of the number of candies consumed revealed some outliers. Thus, data for participants who consumed more than three candies ($n = 9$) were wisterized to three. A 2 by 2 ANOVA on number of candies eaten revealed no main effect for presence, $F(1, 53) = .00$, $p > .05$, partial $\eta^2 = .00$, and no main effect for sex, $F(1, 53) = .17$, $p > .05$, partial $\eta^2 = .00$. (This finding is also significant using the data without the wisterization.) The interaction effect, however, was significant, $F(1, 53) = 4.95$, $p < .03$, partial $\eta^2 = .09$. It should be noted that the Levene's statistic for this test was significant, indicating unequal variances. The ANOVA, however, is a robust test, and the cells were all relatively equal in sample size. Within-sex follow-up tests revealed that low presence females ($M = 2.00$, $SD = 2.95$) ate more candies than high presence females ($M = 0.36$, $SD = 0.94$), $t(16.41) = 2.07$, $p = .055$. High presence males ($M = 2.06$, $SD = 2.79$) ate significantly more candies than low presence males ($M = 0.50$, $SD = 0.67$), $t(17.28) = 2.16$, $p < .05$. Figure 2 depicts these findings.

A 2 by 2 ANOVA (change by sex) was run to ensure that subjective presence was driving this effect rather than the environmental manipulations. Neither the main effect for change, $F(1, 53) = .12$, $p > .05$, partial $\eta^2 = .00$, nor the interaction effect, $F(1, 53) = .07$, $p > .05$, partial $\eta^2 = .00$, were significant.

6 Discussion

This study revealed that viewing one's virtual body change while eating limited the ability to recall numbers. Body change was also related to the self-reported

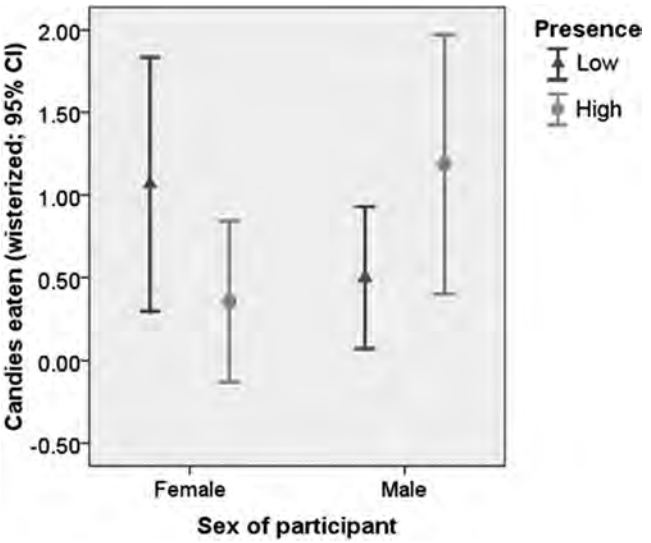

Figure 2. *An illustration of the sex by presence interaction effect on number of candies eaten (wisterized).*

experience of presence: seeing changes kept participants more engaged and they reported higher levels of presence than those in the unchanging condition. When participants were divided into low and high presence groups based on their subjective self-report, it was discovered that those in the high presence group identified fewer numbers than those in the low presence group. A self-reported presence by sex effect was also found on the number of candies consumed; low presence females and high presence males ate more candy than high presence females and low presence males.

This study demonstrated how virtual reality can be incorporated to create engaging stimuli that can be used to influence real world behavior. The nature of this manipulation—being able to see the self experience rapid changes in body composition as it ate—would not be possible using traditional media stimuli. Also, the incorporation of the HMD allowed the user to move his or her head in a natural motion and attend to the parts of the environment he or she wished, perhaps enhancing the experience of presence. It is interesting to note that although the external manipulation of the virtual environment (incorporating a changing body) successfully increased subjective feelings of presence, which in turn predicted imitation, there was no direct effect of change on imitation. Merely seeing the self lose and gain weight was not sufficient to affect eating behavior; rather, it was participants' feelings of involvement and presence with the virtual environment that mattered. Thus, when researchers examine presence, it is important to consider the subjective experience as individual differences may play a greater role in determining outcomes than the researchers' external manipulations to the virtual environment.

One important individual difference to consider is the experience of emotions. Eating behaviors are often closely related to emotions; for example, people seek comfort food when they are experiencing psychological stress. Social pressures and media imagery have also added affective components to eating, such as experiencing guilt after eating a delicious but fattening treat such as bacon, or feeling shameful rather than satiated after consuming a filling meal. Emotions can also impact the experience of presence in virtual environments (Baños et al., 2004). For example, participants who experience anxiety in a virtual simulation also report greater feelings of presence (Bouchard, St-Jacques, Robillard, & Renaud, 2008; Price & Anderson, 2007). Thus, it could be that those with food-related anxiety (e.g., disordered or restrained eaters) experienced greater presence in this study.

Open-ended responses solicited from the high presence participants offered more insight into their experiences in the virtual world. One in the unchanging condition said, "It made me feel like I was the one eating . . . I found myself pretending to eat." A participant in the changing condition stated that the continuous eating "almost made me feel like I was sick or full." Another participant in the changing condition noted:

> I almost want[ed] to feel my body to see if the changes had actually taken place. Even though I really dislike carrots, I liked watching myself get thinner, so watching the weight loss take place made me want to eat more healthily. I love chocolate, so it was difficult to watch myself gain weight. It made me sort of depressed to really visualize that eating chocolate is so unhealthy.

Although these responses were not quantified, they offered further insight to participants' experiences in the virtual world and particularly the nature of their experience of presence.

The findings regarding the number memory task indicate two important things. First, changing stimuli appear to cause greater engagement with the world and higher experiences of presence. Seeing one's body lose and gain weight over a matter of minutes is certainly less realistic than an unchanging body, yet participants still reported higher levels of presence. Because they were more involved in the virtual world, it appears they were devoting their cognitive capacity and attention to observing the world, and their ability to remember the numbers was diminished. Alternatively, as one low presence participant who scored 90% on the memory task noted, "I did not concentrate much on the virtual representation of myself because I was trying to memorize the numbers that appeared." These results indicate that memory task performance may be a good proxy for presence. However, even though subjective ratings of presence and memory task performance were correlated, it is also possible that the memory task was only assessing attention or interest rather than presence. Further exploration of the use of distracter tasks and their relationship to attention, interest, and presence would be fruitful.

It is interesting to note that the self-reported experience of presence had an effect on imitation of the eating behavior, especially in the context of previous studies on sex differences and social facilitation of eating behavior (Herman, Roth, & Polivy, 2003). The interactive effects of sex and presence on modeling behavior are of particular interest in light of this literature. In this study, it is possible that the more realistic the environment and the more engaged participants were with the stimulus (i.e., the more presence they experienced), the hungrier they felt and thus they were more likely to want to imitate the behavior and eat. Prevalent social dietary norms for the sexes then came into play (Baker et al., 2003; Rosen et al., 1988). When men experienced high presence, they ate more candies to satiate the resultant hunger. When women experienced high presence, however, they were more likely to exhibit restraint and not eat candy. It is possible that the more real they felt the environment and self-representation was, the more they experienced body self-awareness. After seeing themselves eat fattening candy, a socially discouraged behavior for women, their impression management behaviors may have been primed, thus leading to restrained eating (Pliner & Chaiken, 1990). The findings of this study are similar to those of Harrison, Taylor, and Marske (2006), who exposed participants to ideal body images and then had them eat in front of same-sex peers. The authors found that after cueing body awareness with these images, women ate less in front of female peers, whereas men ate more in front of male peers. Indeed, future directions of this research should consider incorporating virtual peers, both agents and avatars, to determine their role in the social facilitation and inhibition of eating.

Future research should consider participants' preexisting eating attitudes. Some people demonstrate high levels of eating restraint, and these treatments may affect them differently. Also, participants' satisfaction with their bodies may play a role. Those who do not suffer from body or dietary preoccupation may merely experience hunger and choose to eat after being exposed to an eating model, whereas those who do have body or dietary issues may experience feelings of discomfort or guilt that cause them to consciously avoid eating. Also, future incarnations of this study may attempt to control for participants' consumption before the study (e.g., by asking them not to eat for 2 hr before participation). Effects of multiple exposures may also be of interest. Of anecdotal interest, several of the research assistants for this study reported that after hours of subject-running and watching the stimulus repeatedly, they were constantly hungry and/or craving chocolate. Thus, the utility of this stimulus for various participants may be explored—if it increases hunger, it may be an effective treatment for restrained eaters or those suffering from suppressed appetite due to illness. Alternatively, it may be used to help condition those needing to lose weight to manage their psychological hunger symptoms triggered by such stimuli and instead heed their physical hunger.

There are a vast number of environments in which we

observe virtual models, from video games to online campaigns for health behavior change. This study has demonstrated the importance of assessing presence in the study of virtual stimuli and modeling behavior. If we wish to promote a carryover from virtual experiences to the real world, environments must be created that promote the psychological experience of presence in the user. High presence environments may enhance modeling outcomes and lead to greater imitation in the physical world. Alternatively, decreasing presence may help limit the real world imitation of negative virtual models such as violent video game characters.

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Appendix A

Presence scale items

1. To what extent do you feel the avatar is an extension of yourself?
2. To what extent do you feel that if something happens to the avatar, it feels like it is happening to you?
3. To what extent do you feel you embodied the avatar?
4. To what extent do you feel you were in the same room with the avatar?
5. To what extent did the avatar seem real?
6. To what extent were you involved with the virtual world?
7. To what extent did you feel surrounded by the virtual world?
8. To what extent did you feel like you were inside the virtual world?
9. To what extent did it feel like you visited another place?
10. How much did the virtual world seem like the real world?