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Virtual Self-Modeling: The Effects of Vicarious Reinforcement and Identification on Exercise Behaviors

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Social cognitive theory is often implemented when researchers develop treatments and campaigns for health behavior change. Immersive virtual environment technology (IVET) enables novel explorations of health behavior modeling. In Study 1, participants were randomly assigned to one of three treatments: vicarious reinforcement, in which a virtual representation of the physical self (VRS) gained or lost weight in accordance with participants' physical exercise; an unchanging VRS; or no virtual representation. The reinforcement group performed significantly more exercise in a voluntary phase than those in other conditions. Study 2 separated reward (weight loss) from punishment (weight gain) and also explored model identification by contrasting the effects of a VRS with a VRO (virtual representation of an other); participants exercised significantly more when they viewed the VRS, regardless of whether reward or punishment was shown. In Study 3, participants were exposed to either a VRS running on a treadmill, a VRO running, or a VRS loitering, and we examined effects 24 hours after the experiment. Follow-up surveys revealed that participants in the VRS-running condition demonstrated significantly higher levels of exercise than those in other conditions. We discuss implications for media use and health communication.

Social cognitive theory (Bandura, 1977, 2001) describes the power of a model demonstrating a behavior to encourage modeling by an observer. Several factors, including the similarity of the model, the observer's perceived ability to perform the behavior, and the rewards and punishments associated with

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that behavior predict the likelihood of the observer performing the modeled action. Although these factors effectively influence learning, some may not be easily recreated. Although a "before" and "after" photograph of a model can indicate consequences, long-term effects, such as the gradual damage of sun exposure, are difficult to capture incrementally. Some consequences are simply outside the scope of model reenactment due to financial feasibility, such as recreating the rewarding experience of a venue filled with cheering fans. Others may be harmful, such as having a model smoke a cigarette to demonstrate the punishment of a hacking cough.

Another challenge in creating an effective stimulus is finding the model with the most similarity to the target. In current mass media campaigns, when modeling stimuli are created, the maximum level of physical similarity is limited to matching the model to the observer on categorical variables, such as sex and age (Singhal & Rogers, 2002). Given the strength of model similarity in causing attitude and behavior change (Stotland, 1969), exceeding these categorical variables may be beneficial. With previous efforts, a mirror or a videorecording of the self could capture the model with the highest level of similarity (e.g., Dowrick, 1999). However, those technologies have severe limitations because self-models are constrained by a person's own skill in performing a given behavior. For example, the self could model a tennis serve, but if one is a beginner, the ideal behavior of an ace serve may be too difficult to perform. A professional tennis player could model an ace serve, but this may hamper the individual's feelings of identification with the model because the tennis star is not maximally similar to the self.

Immersive virtual environment technology (IVET) allows researchers to use an individual's photographs to create digital representations of humans that look remarkably like the self. These virtual representations of the self (VRSs; Bailenson, Blascovich, & Guadagno, 2008) can be used to create the ideal model by maximizing feelings of similarity, enabling the demonstration of a wide range of rewards and punishments to the VRS, and customizing the VRS's behavior to portray an optimal performance that the physical self cannot yet achieve. In the current set of three studies, we leveraged the unique aspects of IVET to examine theoretical aspects of social cognitive theory by using the VRS as a model. Participants saw their virtual selves performing health-related behaviors from a third person point of view, and we measured changes in participants' subsequent physical exercise based on this virtual modeling.

SOCIAL COGNITIVE THEORY

Social cognitive theory, originally known as social learning theory, posits that humans can learn behaviors through the observation of models (Bandura, 1977, 2001). The subsequent performance of these learned behaviors is contingent on several factors. The current experiments manipulated two of these constructs: *vicarious reinforcement* and *identification*.

Vicarious Reinforcement

Bandura, Ross, and Ross (1963) noted that children who observed a model rewarded for aggressive behavior were much more likely to imitate that behavior than children who observed a model punished for the same behavior. Rewards served as incentives and punishments were deterrents to imitation of a socially discouraged behavior. *Vicarious reinforcement* suggests that individuals need not experience rewards or punishments themselves in order to learn behaviors; rather, they can observe and interpret the consequences experienced by a model and make inferences as to the likelihood of incurring these outcomes themselves.

Vicarious reinforcement has been used to demonstrate the benefits and risks associated with health-related behaviors. For example, showing negative consequences in public health campaigns is expected to discourage observers from smoking or abusing drugs by showing models punished with appalling physical symptoms or harmed social relationships (Witte & Allen, 2000). Entertainment-education efforts rooted in the principles of social cognitive theory often portray the rewards and punishments associated with health behaviors through plot lines in television and radio shows (Singhal & Rogers, 2002). For example, a recent story arc on the television drama *ER* addressed adolescent obesity by featuring a doctor advising an obese teen with high blood pressure to eat more fruits and vegetables and get more exercise (Valente et al., 2007). Vicarious reinforcement of these mediated models led to positive changes. Compared to non-viewers, viewers reported exercising more, eating more fruits and vegetables, and being more likely to get their blood pressure checked.

Identification

Identification refers to the extent to which an individual relates to a model and feels that he or she is similar to the model. Identification has been shown to increase the likelihood of performing learned behaviors (Bandura, 2001; Bandura & Huston, 1961). Observers must feel that the model is similar enough to them that they are able to experience the same outcomes. Similarity may be based on physical traits, personality variables, or shared beliefs and attitudes (Stotland, 1969). Indeed, the likelihood of learning increases when models are of the same sex (Andsager, Bemker, Choi, & Torwel, 2006), race (Ito, Kalyanaraman, Brown, & Miller, 2008), or skill level (Meichenbaum, 1971), as well as when models demonstrate similar opinions (Hilmert, Kulik, & Christenfeld, 2006) or previous behaviors (Andsager et al., 2006).

Many mediated messages about health behaviors use models similar to the target audience to foster identification. Entertainment-education efforts typically match the characters serving as models with the target audience in terms of physical characteristics as well as beliefs, attitudes, and behaviors in order to achieve the highest levels of identification, which in turn are expected to impact modeling behavior (Singhal & Rogers, 2002). Ito et al. (2008) created an interactive CD-ROM that offered its female adolescent participants their choice of avatars to guide them through information about sexually transmitted infections; over 60% of participants chose avatars of the same race or ethnicity. It is likely the participants identified more highly with these guides, and the authors speculated that this may influence message effectiveness. Andsager et al. (2006) found that perceived similarity to a model in an anti-alcohol advertisement was positively related to the message's effectiveness. These mass messages, however, cannot achieve highly specific models for each individual audience member. Thus, it may be that some of the message's potency is lost by the individual's inability to identify with a given model. New technologies present researchers with the opportunities to maximize identification with a model.

IVET AND PSYCHOLOGICAL RESEARCH

Immersive virtual environment technology (IVET) enables researchers to create novel experimental simulations. IVET is largely defined by two characteristics: the replacement of natural sensory information with digital information and the ability to track and respond to users' movements in order to tailor that digital information (Blascovich, 2001; Blascovich et al., 2002). One of the most commonly implemented devices is a *head-mounted display* (HMD), a helmet or headpiece with LCD screens fitted in front of the eyes that helps provide a wide, stereoscopic view of the computer-generated environment. The image drawn inside the HMD depends on the information given by the *tracking* apparatus. Various devices can capture simple head movements, such as turning the head in different directions; the position of the body in three-dimensional space (e.g., walking around a room); or body movements, such as waving a hand or changing posture. Figure 1 illustrates the components of IVET.

Thus, the virtual environment reacts in a naturalistic way to the user's actions. This enhances the experience of *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; Loomis, 1992). The user's feelings of presence may enhance the experience and effects of a virtual environment (Skalski & Tamborini, 2007). Participants inside an IVET simulation often describe the experience as "being in a movie." Unlike a movie, however, IVET is

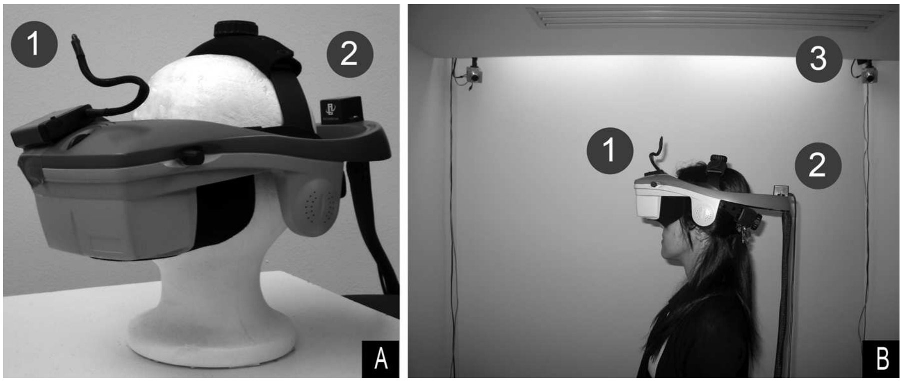

FIGURE 1 A close-up (A) shows the features of the head-mounted display (HMD). A participant dons an HMD (B). An optical marker (1) is tracked by four cameras in the corners of the room (3), providing high resolution data about her location in X, Y, Z space in the room. An accelerometer (2) provides data about her head rotations. A rendering machine assimilates these data streams to create the appropriate visual output for every move made by the participant.

characterized by interactivity, which has been shown to be an influential feature in other media (Bucy & Tao, 2007; Sundar, 2007). Users have the opportunity to engage with a responsive environment and virtual humans whose behaviors are contingent on the user's actions. Thus, interactivity allows the user to be both an observer and a participant in the environment, possibly leading to different or more potent media effects (Vorderer, 2000).

IVET has been used to replicate "real world" studies as well as examine novel phenomena in the virtual world. IVET has been incorporated in studies of persuasion (Guadagno, Blascovich, Bailenson, & McCall, 2007), obedience (Slater et al., 2006), behavioral mimicry (Bailenson & Yee, 2005), and videogame violence and aggression (Persky & Blascovich, 2007). Additionally, virtual environments have been effective in achieving positive health changes in both cognitive and physical therapy (Rothbaum, Hodges, Smith, Lee, & Price, 2000; Sveistrup et al., 2003). Incorporating IVET in exercise-based fitness efforts is a logical step. Chuang and colleagues (2003) examined participants' exertion while cycling on a stationary bike in a virtual or real environment; participants in the virtual environment cycled for a longer period of time, covered more distance, and expended more calories than participants who cycled without it. Similarly, Plante, Aldridge, Bogden, and Hanelin (2003) found that participants who exercised in a virtual environment rather than a real environment experienced less tiredness and reported more energy and enjoyment. These studies demonstrate that IVET can keep participants motivated while exercising, potentially enhancing exertion and intensity as well as long-term adherence. Although these treatments were successful, they did not incorporate relevant theoretical constructs that may influence health-related outcomes (Fishbein & Cappella, 2006). Theories of health behavior change may help create more powerful stimuli.

Manipulating Social Cognitive Theory Constructs through IVET

Social cognitive theory provides a useful framework for the creation of these treatments. As Bandura (2002) noted, "symbolic modeling lends itself readily for society-wide applications through creative use of the electronic media" (p. 12). Indeed, virtual humans are useful models as they can be manipulated to portray a range of desirable behaviors that may be difficult to enact in the real world. Also, virtual humans can portray the highest level of similarity, including the same age, sex, skill level, or emotional state as the individual. Such similarities can help people develop feelings of identification with and empathy toward virtual humans (Gilliath, McCall, Shaver, & Blascovich, 2008), increasing their effectiveness as models and persuasive agents.

Recently, technologies have been developed to create virtual humans that bear strong resemblance to individuals (Bailenson, Beall, Blascovich, & Rex, 2004; Bailenson et al., 2008). Through the use of digital photographs and head-modeling software, an individual's visage may be replicated in the virtual world. Figure 2 depicts an example of a VRS. Although this transference is not flawless, it creates relatively accurate models of the human form.

The use of the VRS as a model has many advantages over traditional self-modeling efforts. For example, an obese man might have difficulty envisioning himself thinner or a thin man might not be able to fathom gaining muscle mass. In the virtual world, these rewards can be portrayed as the VRS can be altered to represent different levels of attainable or ideal body states. This vicarious reinforcement may motivate those seeking to make a significant lifestyle change; not only would the individual experience high identification with the VRS, but seeing the virtual evolution might convince him or her that such changes are achievable.

OVERVIEW OF EXPERIMENTS

We designed three experiments to manipulate constructs of social cognitive theory in the health behavior context. The first study addressed vicarious reinforcement by creating a treatment that depicted the VRS experiencing health rewards associated with exercise and the punishments associated with inactivity. Participants witnessed the VRS gain or lose weight in immediate accordance with his or her physical exercise behaviors, a stimulus that would not have been possible before the development of IVET. The second study considered virtual weight loss separately from gain to see if reward and

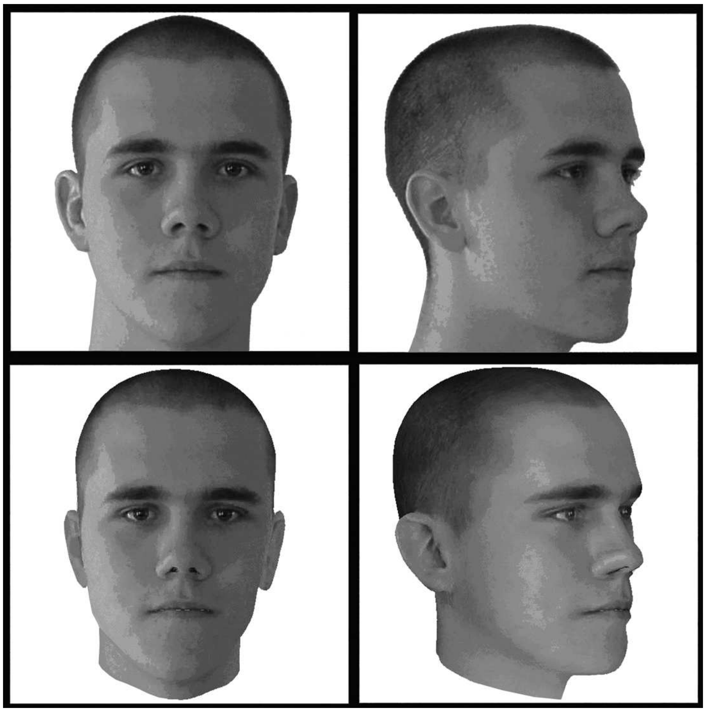

FIGURE 2 A person's photographs are taken at two different angles (top row) and then are converted into a three-dimensional head model (bottom row) used to create the VRS with high facial similarity.

punishment differentially affected modeling; additionally, this study introduced a self-other manipulation to determine if an unfamiliar VRO (virtual representation of an other) was as effective as a VRS. The third study also focused on the mechanism of identification by showing participants a VRS running on a treadmill, a VRS standing still, or a VRO running. Rather than considering immediate effects, this study explored whether effects would persist over time and stimulate exercise behaviors in the real world.

STUDY 1

This study investigated the use of VRSs as exercise models in a virtual environment. We hypothesized that seeing a VRS being rewarded for the participant's physical exercise (through apparent weight loss) and punished for the participant's inactivity (through apparent weight gain), as opposed to seeing an unchanging VRS or no virtual human, would cause participants to engage in more voluntary exercise (H1). We included an unchanging VRS as a control to determine whether it was vicarious reinforcement of the self that induced the participant's exercise; the condition without a virtual human was included to ensure that the effect was not merely seeing the self that instigated exercise.

Method

Sample. A convenience sample was recruited from the student population of a medium-sized West Coast university. Participants were offered $10 or course credit for their participation. The sample ($N = 63$) consisted of 31 women and 32 men aged 18 to 29 ($M = 20.28$, $SD = 1.70$).[1]

Apparatus. Participants were placed in a fully immersive virtual environment. They donned a HMD through which they viewed the treatment. Sensing equipment tracked users' motions (e.g., walking, head movement) so that a realistic visual depiction of the environment could be updated constantly based on their movements. Figure 1 depicts the room set up and a close-up of the HMD (detailed equipment specifications can be found in Yee & Bailenson, 2007).

Design and procedure. A between-subjects design was employed for this experiment. Participants were randomly assigned to one of three conditions: *reinforcement* ($n = 22$), *no change* ($n = 22$), or *no virtual human* ($n = 19$).

Participants had their photographs taken with a digital camera for a presumably unrelated study. Approximately six weeks 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. For the VRS conditions, these heads were affixed to a sex-appropriate generic human body. Modeling was limited to the head as modeling the physical body was beyond the human and technological resources allotted to these studies.

Participants in all three conditions were provided with the same fitness prompt: "One of the greatest health issues facing Americans is physical inactivity. Exercise is essential to maintaining a healthy body. A lack of exercise can lead to several health problems, including obesity and cardiovascular disease. According to the Surgeon General, people need at least 30 minutes of physical activity a day in order to maintain their weight."

Next, participants were provided with a printout portraying a combination arm and shoulder exercise. The research assistant demonstrated the exercise once, pausing to describe each movement. Participants were handed two-pound weights, and they performed the exercise slowly so that the research assistant could correct the motion as needed before the treatment commenced. Then, the participant was immersed in the virtual environment.

The experiment was structured in three phases that were consistent across conditions. In the first phase, participants performed three sets of

12 exercises each. In the second phase, participants stood still for two minutes. The third phase was voluntary; participants were told they could stay in the virtual environment and exercise or they could end the experiment.

Although the phases were the same across conditions, there were differences in what the participants observed in each condition. In the no virtual human condition, participants saw nothing but an empty virtual room. In the other two conditions, participants viewed their VRSs from the third person, consistent with previous research involving VRSs (Bailenson et al., 2008). That is, the participant did not embody the virtual self; the VRS was standing in the room facing the participant. In the no change condition, participants saw their own VRSs at an approximately average weight and body shape in the virtual room, but their virtual bodies did not change for the duration of the experiment. In the *reinforcement* condition, the VRS started at the same average body weight as in the no change condition, but participants saw their VRSs appear to lose weight as participants physically exercised or gain weight as they remained inactive. In the first phase, for each repetition of the exercise, the VRS was scaled down 1% on the x-axis, slimming the VRS by narrowing the body. In the second phase of mandatory inactivity, for each three seconds the slimmed-down VRS was scaled up 1% on the x-axis, widening the body until it was overweight. For the third phase, the VRS was reset to the initial, average weight, and then the VRS appeared to lose or gain weight in accordance with the participant's exercise or inactivity by the same percentages as the first two phases.

The dependent variable was *exercise repetitions.* A research assistant counted each exercise repetition participants performed during the voluntary third phase of the experiment and recorded each with a keystroke. Exercise repetitions ranged from 0 to 51 ($M = 6.38$; $SD = 13.76$).

Results and Discussion

To test H1, we ran a one-way ANOVA with condition as the independent variable and exercise repetitions as the dependent variable. There were significant differences between the treatment groups, $F(2, 60) = 11.08$, $p < .0005$, partial $\eta^2 = .27$. A follow-up Fisher's Least Significant Difference (LSD) test revealed that the only significant differences were that participants in the reinforcement condition exercised more frequently ($M = 16.04$, $SD = 19.35$) than participants in the no change ($M = 1.68$, $SD = 5.23$) and no virtual human ($M = 0.63$, $SD = 2.75$) conditions.

In support of H1, these findings indicated that vicarious reinforcement was successful: Seeing the VRS rewarded for performing an exercise behavior and then punished for not performing it encouraged exercise behavior. Simply being immersed in a virtual environment or seeing the static VRS in a virtual environment while exercising was not sufficient. Observing the VRS losing weight in accordance with one's physical exercise and seeing the

VRS gain weight due to physical inactivity effectively encouraged participants to engage in exercise.

Although this study determined that a changing VRS was an effective stimulus, it is not clear whether it was the reward of the self losing weight or the punishment of the self gaining weight that motivated participants to exercise. Also, there was no control condition to suggest that seeing *any* virtual human would be effective. The second study addressed these questions.

STUDY 2

This study was designed to determine if either portrayals of reward or punishment were more effective in increasing exercise behavior. Previous studies on exercise motivation have indicated that the promise of reward often leads to increased exertion (Buckworth, Lee, Regan, Schneider, & DiClemente, 2007). Thus, it was hypothesized that those in the reward conditions would exercise more than those in the punishment conditions (H2). Additionally, this study addressed the concept of identification through similarity with the model. We used virtual humans that looked similar or dissimilar to the self as exercise models to determine whether the virtual self was essential, or if any virtual model could achieve the same effects. Because model similarity might promote identification and thus performance, we hypothesized that the VRS would be a more effective model than a VRO (H3).

Method

Sample. A convenience sample was recruited from the student population of a medium-sized West Coast university. Participants received $10 or course credit for participation. An initial sample of 60 was obtained; due to technological failure, seven participants were dropped from analyses. The final sample ($N = 53$) included 21 women and 32 men aged 18 to 55 ($M = 20.54$, $SD = 5.81$).

Design and procedure. A 2 × 2 between-subjects design was employed for this experiment. Participants were randomly assigned to one of four conditions: *VRS-reward* ($n = 14$), *VRS-punishment* ($n = 12$), *VRO-reward* ($n = 14$), or *VRO-punishment* ($n = 13$).

The same photograph and head-modeling procedure used in the first study was employed in Study 2. For the VRS conditions, participants' heads were affixed to a sex-appropriate generic human body. For the VRO conditions, the virtual human featured an unknown person's head of the same sex and approximately the same age that was selected randomly for each participant from a pool of past experimental participants not involved in the current study.

Participants in all three conditions were provided with the same fitness prompt as Study 1. Participants in the reward conditions were informed their avatars would be losing weight in accordance with their exercise; those in the punishment conditions were informed their avatars would be gaining weight in accordance with their inactivity. Next, the research assistant demonstrated the exercise for this study, marching in place. A different exercise was chosen to increase generalizability. Participants were instructed to lift their right knee to waist level and then return their right foot to the ground; then they repeated the action with their left leg. A right-leg, left-leg sequence was counted as one repetition. The research assistant demonstrated the exercise once slowly and then once at a normal pace to show how the repetitions would be counted. Then, the participant was immersed in the virtual environment.

All three conditions were structured in three phases similar to the previous study. In the first phase, participants performed three sets of 20 exercises each. In the second phase, participants were asked to stand as still as possible for two minutes. Participants were told the third phase was voluntary; they could stay in the virtual environment and exercise if they wished or they could end the experiment. In all conditions, similar to the first study, participants saw their virtual representations from the third-person perspective. As participants exercised in the physical world, their virtual selves also exercised. In the first phase of the VRS-reward condition, participants saw the VRS lose weight as they performed the mandatory exercises. In the second phase, the VRS remained inactive, but no consequences were shown for inactivity. In the third phase, if the participant chose to exercise, the VRS exercised and lost weight. If the participant did not exercise, no consequences were shown. The VRO-reward condition was similar except that participants saw a virtual other instead of the virtual self. Thus, in the reward conditions, no punishment was shown for inactivity; only reward was shown for exercise. In the VRS-punishment condition, the VRS did not lose weight in the first phase as participants exercised. In the second phase, as the participant was inactive, the VRS gained weight. In the third phase, if the participant chose to exercise, the VRS exercised but did not change; if the participant was inactive, the VRS gained weight. The VRO-punishment condition was the same except that a virtual other was the model. Thus, in the punishment conditions, no reward was shown for the desired behavior, only punishment for the undesired behavior.

Measures

Exercise repetitions. As in Study 1, the dependent variable of interest was exercise repetitions. A research assistant counted each exercise repetition participants performed during the voluntary third phase of the experiment and recorded each with a keystroke. Forty-three participants (81%) chose to exercise during the third phase; the number of repetitions performed ranged from 0 to 215 ($M = 44.87$; $SD = 51.05$).

Virtual human resemblance. In order to ensure that the self-other manipulation was successful, participants were asked to indicate on a fully labeled 5-point scale the degree to which they felt the virtual human resembled them (1 = *definitely did not look like me at all*; 5 = *definitely looked a lot like me*; $M = 2.35$, $SD = 1.06$). Participants in the VRS conditions ($M = 2.71$, $SD = .98$) reported that the virtual human looked more like them than participants in the VRO conditions ($M = 1.96$, $SD = 1.02$), $t(53) = 2.79$, $p < .01$, confirming that the self-other manipulation was successful.

Results and Discussion

Hypotheses. A 2 × 2 ANOVA was performed to determine the effect of conditions on exercise repetitions. Regarding main effects, H2 was not supported. There was no difference between reward ($M = 49.07$, $SD = 49.33$) and punishment ($M = 40.14$, $SD = 53.52$) conditions, $F(1, 49) = .38$, $p > .05$, partial $\eta^2 = .01$. The self-other hypothesis (H3) was confirmed: those in the self conditions performed significantly more exercises ($M = 62.23$, $SD = 64.17$) than those in the other conditions ($M = 28.15$, $SD = 25.70$), $F(1, 49) = 6.15$, $p < .02$, partial $\eta^2 = .11$.[2] The interaction effect was not significant, $F(1, 49) = .14$, $p > .05$, partial $\eta^2 = .00$.

This study determined that the virtual self is a model that can be used to encourage exercise, whereas a virtual other is not sufficient. Using the virtual self, this study did not detect any differences regarding whether the participant was rewarded for their exercise or punished for not exercising: Either manipulation stimulated exercise. The small sample for this study may have prevented finding a difference between rewards or punishments, however. Alternatively, the benefit of weight loss and the threat of weight gain as depicted in this manipulation may have been qualitatively equivalent.

The first two studies were limited in that they only assessed exercise behavior in the laboratory immediately following the treatment. Possibly, these treatments may have carried over outside of the laboratory and encouraged more exercise after the experiment. Also, the first two studies involved the participant physically performing an exercise; it is possible that this served as a "warm-up" for subsequent physical behavior. It may be possible to encourage exercise behavior without the participant having to engage in the behavior in the lab, and that merely exposing someone to his or her VRS exercising can cause an increase in health behavior. Thus, the next study considered identification independent of vicarious reinforcement.

STUDY 3

According to social cognitive theory, observing a model similar to the self should cause greater learning than observing a dissimilar model (Bandura, 1977, 2001). One possible explanation is that greater identification with a model leads to more learning because it is easier to visualize the self in the place of the model. In a sense, high identification may lead to a sort of embodiment wherein the observer really feels as if he or she is having the same experience as the model. If the model is in fact a representation of the self, this feeling may be even stronger, which may lead to a greater likelihood of performing the behavior.

Similar to Study 2, this study explored the use of virtual humans that looked similar and dissimilar to the self as exercise models in a virtual environment. Rather than examining immediate effects inside the laboratory, this study focused on whether these stimuli caused participants to exercise later in the physical world. A VRS exercising should maximize identification, whereas a VRO matched solely on the categorical variables of sex and age should provide a limited degree of identification. Thus, we hypothesized that seeing a VRS running, as opposed to a VRO running or VRS loitering, would increase participants' physical activity following exposure (H4).

Method

Sample. A convenience sample was recruited from the student population of a medium-sized West Coast university. Participants were offered \$10 or course credit for their participation. An initial sample of 75 was obtained; two participants failed to complete the follow up survey and their data were excluded from the analyses, leaving a sample of $N = 73$, including 50 women and 23 men aged 18 to 33 ($M = 20.61$, $SD = 2.50$).

Design and procedure. A between-subjects design was employed. Participants were randomly assigned to one of three conditions: *VRS-running* ($n = 25$), *VRS-loitering* ($n = 24$), or *VRO-running* ($n = 24$). None of the participants from this study had participated in the first or second study.

The same photograph and head-modeling procedure used in the first two studies was employed in Study 3. In all three conditions, participants observed a virtual human for 5 minutes 20 seconds. During this time, they engaged in a distractor task in which they focused on a sequence of 20 numbers that flashed on the virtual human's chest for later recall. The purpose of the distractor task, derived from 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. In the VRS-running condition, the virtual human was running on a treadmill and featured the participant's face on a sex-appropriate generic virtual human body. In the VRO-running condition, the only difference was that the virtual human

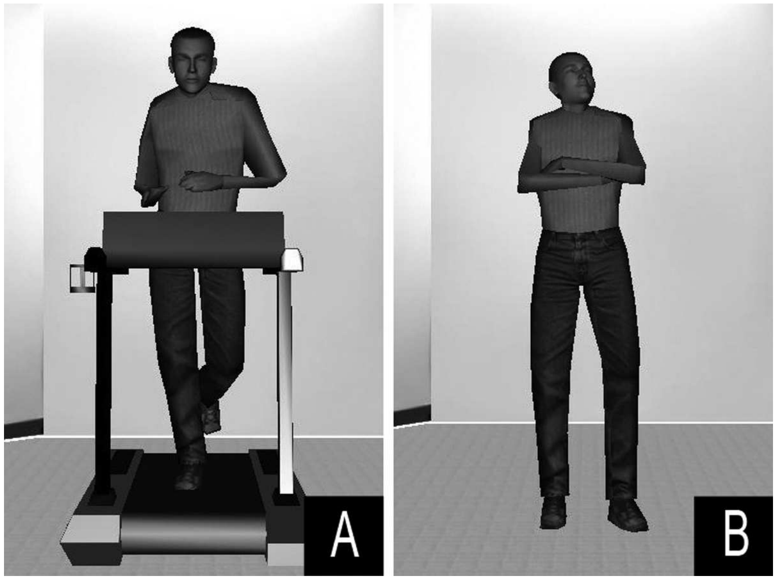

FIGURE 3 A running virtual representation (A) and a loitering virtual representation (B).

featured another unknown person's face of the same sex and approximately the same age that was selected randomly for each participant from a pool of past experimental participants not involved in the current study. In the VRS-loitering condition, the virtual human was standing, shifting its weight, and occasionally crossing its arms; the participant's face was featured on a sex-appropriate generic virtual human body. Figure 3 provides examples of running and loitering virtual humans.

Twenty-four hours after the experiment ended, the researcher called all participants to remind them to fill out the survey and emailed the survey link. Participants who had indicated they would not be near a computer 24 hours following the experiment ($n = 9$) had been provided with a sealed survey to complete; later, they submitted those responses electronically.

Measures[3]

Virtual human resemblance. Participants were asked to rate on a fully labeled 5-point scale the degree to which they felt the virtual human resembled them (1 = *definitely did not look like me at all*; 5 = *definitely looked a lot like me*; $M = 2.45$, $SD = 0.94$). This served as a manipulation check to ensure that participants felt they were viewing a VRS as opposed to a VRO. A one-way ANOVA determined there were significant differences between the three conditions, $F(2, 72) = 9.56$, $p < .001$, partial $\eta^2 = 0.22$. A follow-up Fisher's LSD test at $\alpha = .05$ revealed that participants rated the virtual humans in the VRO condition ($M = 1.83$, $SD = 0.92$) as resembling themselves significantly less than participants in the VRS-running ($M = 2.72$, $SD = 0.89$) or VRS-loitering ($M = 2.79$, $SD = 0.72$) conditions.

Paffenbarger Physical Activity Questionnaire. A modified version of the Paffenbarger Physical Activity Questionnaire (PPAQ; Paffenbarger, Wing, & Hyde, 1978) was administered in the follow-up survey. Participants were asked to reflect on the 24 hours that had transpired since the experiment ended. They reported how many city blocks (or miles) they had walked and how many flights of stairs they had climbed. Participants were provided with a list of activities representing nine levels of metabolic equivalent (MET, essentially a measure of calorie burn) activity ranging from sleeping to vigorous activity. They were asked to indicate how much time (in 15-minute increments) they had engaged in these or similar activities over the past 24 hours (following Aadahl & Jørgensen, 2003). The items of interest were those that involved physical activity, which included city blocks walked, flights of stairs climbed, and the four highest levels of MET activity: 4.0 MET (bicycling and brisk walking), 5.0 MET (carrying and loading items), 6.0 MET (aerobics or other health club exercise), and >6.0 MET (intense exercise such as running or playing soccer). Appendix A lists the exact wording of these questions.

Intent of study. Participants were asked to speculate on the intent of the study. Both the researcher and an independent coder blind to experimental condition evaluated the written open-ended responses for any mention of modeling or mimicking the virtual human's activity. No participant correctly identified its purpose.

Results and Discussion

Hypothesis. To address H4, the items that entailed physical activity were examined. Because these items used different units of analysis, the variables were standardized and *Z*-scores were derived. Next, a principal components analysis with Promax rotation was performed on the six physical activity items. Three items loaded on the first factor, which explained 28% of the variance; two items loaded on the second factor, which explained 24% of the variance. One item loaded equally on both factors and was consequently dropped from further analyses. The items and factor loadings can be viewed in Table 1; Table 2 shows the correlations between items.

The three items that loaded on the first factor (number of blocks walked, number of flights of stairs climbed, and other activities at 4.0 MET such as bicycle riding) were termed "commute," as these activities generally reflect the activity required to get to or from places and are likely related to commuting. The two items on the second factor, exercise and intense exercise, were labeled "exercise." These items reflected activities aside from everyday transportation that required time beyond the work day. Although the Kaiser-Meyer-Olkin (K-M-O) statistic for the factors was low (.51), it

TABLE 1 Factor Loadings for Physical Activity Items

	Commute	Exercise
Commute		
City blocks walked	.785	.061
Flights of stairs climbed	.582	.175
Biking, brisk walking (activity at 4.0 MET)	.653	−.186
Exercise		
Aerobics, gym workout (activity at 6.0 MET)	−.004	.757
Running, playing soccer (activity at >6.0 MET)	.050	.748

Factor 1, Commute, explains 27.81% of variance; Factor 2, Exercise, explains 23.85% of variance.

exceeded the threshold for factor analysis (Kaiser, 1974). Additionally, the two factors parallel those identified by Baecke, Burema, and Fritjers (1982).

The three conditions were compared on each of these two factors. A one-way ANOVA found no significant differences between the VRS-running ($M = -0.14$, $SD = 0.79$), VRO-running ($M = -0.00$, $SD = 1.09$), and VRS-loitering ($M = 0.15$, $SD = 1.12$) conditions for the commute items, $F(2, 70) = .48$, $p > .05$, partial $\eta^2 = .01$. In contrast, an ANOVA revealed significant differences across conditions for the exercise items, $F(2, 70) = 3.51$, $p < .05$, partial $\eta^2 = 0.09$. Follow-up LSD tests at $\alpha = .05$ showed that participants in the VRS-running condition engaged in significantly more exercise ($M = 0.42$, $SD = 1.22$) than participants in the VRO-running ($M = -0.21$, $SD = 0.62$) and VRS-loitering ($M = -0.22$, $SD = 0.95$) conditions. When we look at the data in actual minutes as opposed to factor scores, participants in the VRS-running condition ($M = 142.2$, $SD = 146.02$) engaged in over an hour more voluntary exercise independent of commuting than participants in the VRO-running ($M = 66.88$, $SD = 65.00$) and VRS-loitering ($M = 61.88$, $SD = 94.80$) conditions.

These findings indicate that seeing one's VRS model an exercise behavior stimulates the performance of exercise behavior in the individual. It was not merely seeing a VRS that encouraged this behavior, as seeing the VRS loitering did not lead to an increase in activity. Also, seeing a VRO exercise was not sufficient to encourage the individual to exercise. Of course, this

TABLE 2 Correlation Matrix for Factor Items

	C1 Blocks	C2 Stairs	C3 Biking	E1 Exercise	E2 Intense Ex
C1 Blocks	—	.23*	.26*	.05	.02
C2 Stairs		—	.07	.01	.06
C3 Biking			—	−.05	−.01
E1 Exercise				—	.18
E2 Intense Ex					—

*$p < .05$.

finding should be considered within its context, among an active college population in a health-oriented area of the country.

It is important to note that these results are preliminary, as the factor analysis showed a less than desirable K-M-O statistic. The correlations between items on the scales were low, but this may be due to the zero-sum nature of activity over a twenty-four hour period; for example, exercise at a very high intensity might displace the hours spent exercising at a regular intensity. Thus, further examination of these factors is necessary.

GENERAL DISCUSSION

Summary of Findings

The three studies presented above indicate that virtual self-models can be effective instigators of health behavior change. In the first study, participants who witnessed the reward and punishment of their VRSs engaged in more voluntary exercise than those who saw an unchanging VRS or no virtual human. The second study determined that either the reward of the VRS losing weight or the punishment of the VRS gaining weight was sufficient to encourage participants to exercise, whereas observing either change in a VRO was not. In the third study, participants who viewed their VRS exercising engaged in more exercise in the 24 hours following the experiment than participants who viewed their VRS loitering or a VRO exercising.[4]

Theoretical Implications

These results indicate that IVET presents a rich opportunity to explore the full spectrum of social cognitive theory beyond traditional methods. The typical manipulation of identification involves matching the model to the observer on basic characteristics. Here, Studies 2 and 3 demonstrated that a self-model is more effective than a model matched solely on sex and age, which represents the extent of many media messages invoking health behavior change.

Additionally, these results indicate that vicarious reinforcement of a "self" model, as opposed to an "other" model, sufficiently motivates exercise. Surprisingly, we found no differences between the effects of rewards and punishments, as long as they were experienced by the virtual self. However, this is consistent with a recent study by Nabi and Clark (2008) that found similar results. They exposed participants to television clips depicting the rewards and punishments associated with promiscuous sexual behavior and found that participants who had not engaged in such behavior indicated that they would model that behavior in the future, regardless of whether they had seen rewards or punishments. Thus, as Nabi and Clark suggest, it could be that outcome expectancies associated with a behavior dictate participants' behaviors in spite of the rewards and punishments experienced by a particular model. In Study 2, participants were likely aware that exercise has positive health benefits, and this may have led to modeling regardless of our manipulation in which the model experienced rewards or not. Future research is needed to further explicate the mechanism behind this effect.

One shortcoming of these studies is that the role of self-efficacy was not examined. Believing that one is able to exercise, lose weight, and maintain a healthy routine has been shown to be a significant contributor to adherence to diet and fitness plans (Bandura, 1997). It is possible that the treatments enhanced or diminished feelings of self-efficacy, which then affected the participant's exercise. Future studies might also assess participants' exercise-related self-efficacy before exposure to determine if treatments are differentially effective for those with low or high self-efficacy. Also, it should be determined if the instant gratification of immediate virtual weight loss, an unrealistic occurrence in the real world, impacts self-efficacy in the long term.

Another possible explanation for this effect is that seeing oneself exercise in the virtual world may trigger memories of good feelings from previous exercise experiences or instigate feelings of guilt considering the consequences of not exercising. The experience of affect, such as the fear of gaining weight and becoming unattractive, or the accompanying cognitive dissonance may motivate individuals to engage in exercise. Because the third study did not incorporate explicit modeling instructions, another consideration is the possibility of unconscious mimicry occurring (Chartrand & Bargh, 1999). Indeed, emergent research is addressing whether the influence of avatars' behavior on their users is driven by conscious or nonconscious processes, such as priming (Yee, 2007). Determining the role of self-efficacy may also help distinguish between modeling and priming forces at work.

Methodological Implications

Previous research achieved the highest level of model similarity by videorecording the self performing a desired behavior (Dowrick, 1999). This method is limited, however, by the self-model's ability to perform that behavior at the desired level. In these studies, IVET resolved this limitation by incorporating a self-model that promoted both the highest level of identification with the observer and also demonstrated the optimal level of behavior.

IVET also enhances researchers' capabilities to manipulate vicarious reinforcement. Rewards and punishments can be presented at a much broader range of increments, helping observers recognize even the smallest consequences of modeling a behavior. This reinforcement can also accommodate individuals' distinct levels of progress and incorporate a visual representation of that progress as well as future goals. For example, if a person losing weight hits a plateau, he or she might regain some motivation seeing the virtual self at the initial weight, transitioning to the current weight, and then proceeding to lose the remaining weight.

Thus, through the use of IVET, we can create ideal models that maximize both feelings of identification and the experience of vicarious reinforcement, presenting new opportunities for theoretically-based health interventions (Fishbein & Cappella, 2006). Several scholars working with health campaigns and entertainment-education have argued for the effectiveness of tailoring mass messages to create individual-specific treatments (Bock, Marcus, Pinto, & Forsyth, 2001; Hawkins, Kreuter, Resnicow, Fishbein, & Dijkstra, 2008; Singhal & Rogers, 2002). A VRS represents the most individually tailored model possible, and IVET allows us to customize the stimulus in unprecedented ways, enabling responsive treatments that incorporate individual goals, various contexts, or new obstacles to change. Future research should explore such tailoring as it could enhance the individual's self-efficacy as well as his or her efforts to manage health behavior.

Limitations and Future Directions

There were limitations to the individual studies that should be addressed in future iterations. Studies 1 and 2 had a research assistant perform the exercise once or twice before the stimulus, and there were no measures of identification with the research assistant. Future studies might eliminate this demonstration to remove any confounding effects of viewing a human performance. Study 2 had a relatively small number of participants ($N = 53$), which may have limited the ability to detect differences across the reward and punishment manipulations. Due to the low correlations and K-M-O statistic, the factors identified in Study 3 warrant further investigation. Also, the follow-up survey used in Study 3 relied on self-report data, which may be subject to bias, rather than observation. Additionally, pre-test data about the participants' regular exercise behaviors would have provided baseline measurements. Across studies, such data could have enabled the identification of generally active versus inactive individuals and allowed comparisons between these groups. Future studies should collect and possibly control for more detailed biographical information from participants.

Another limitation is the possibility of demand characteristics. In Studies 1 and 2, the participants were guided through two phases and then could choose to stay in the world and exercise or terminate the experiment. It is possible that participants felt compelled to stay in the world and exercise to satisfy the experimenter. However, participants clearly know the goal of prosocial media campaigns (exercising is good for you) as well as the expected behavior (exercise more). It is important that the VRS actually caused them to actively engage in exercise, regardless of whether they knew the purpose of the experiment. In other words, demand characteristics in questionnaires are a concern, but if a participant is willing to engage in demanding physical labor merely to act in line with the campaign in the experiment, then it is an effective message. In Study 3, it is possible that participants had figured out the purpose of the study and were self-reporting accordingly, however the data gauging the intent of the study argues against this notion. Nonetheless, it is impossible to completely rule out some level of demand characteristics from the current work.

A technological limitation of these studies is that the VRS similarity was restricted to the face; unfortunately, limited human and technological resources prohibited individually capturing and modeling each participant's body in addition to the face. Future research may collect data on participants' body type or body mass index (BMI) and manipulate body similarity as well. On a related note, it is possible that self-reported feelings of resemblance in the VRS conditions was relatively low because the measures did not distinguish between facial and bodily resemblance; future studies should make this distinction.

One final limitation of these studies is that they did not explore the concept of presence. Considering that seeing a disembodied version of the self may itself be a cue to the unrealistic nature of the setting, it could be that the experience of presence is hindered. Alternatively, the promotion of identification with a self-representation may bolster feelings of self-presence. Future studies should examine how VRSs influence feelings of presence, and whether presence influences behaviors both inside and outside of the virtual experience. Also, although photorealistic VRSs are not yet widely available in applications, many do offer the option of highly customizable avatars; thus, the conceptual work on self-representation here could be explored using commercially available technologies, such as the Wii Fit. Ratan, Santa Cruz, and Vorderer (2008) found that self-similarity to a Wii avatar increased *self-presence*, the feeling that the embodied virtual self is the real self, and found a borderline significant effect of self-presence on memory while multitasking. One extension of our current line of studies could examine whether an avatar that is made to look dissimilar or as self-similar as possible influences a user's ability, skill development, physiological response, or physical exertion level while playing, and whether these effects hold over time.

CONCLUSIONS

These studies have shown that new technologies such as IVET have the potential to revolutionize efforts at health behavior change. We have the capability to create ideal self-models that can motivate individuals to adopt new health practices or positively modify existing ones. These models were successfully implemented in an exercise treatment; many other contexts may benefit. They may be incorporated as part of a long-term program to influence desirable behaviors that often have low adherence or retention, such as healthy eating behaviors or beneficial medical treatments.

At this stage, it is important to determine the potency of VRSs outside of immersive virtual environments as they may also have a role in other treatments, such as desktop applications or healthful video games. A cubicle-bound employee could watch a brief segment of his VRS exercising to motivate him to hit the gym during lunch hour. Upon his return, he could log his activity and his VRS could show the rewards of engaging in that level of activity over time or show how stepping up his intensity may be even more rewarding. An obese child could see her VRS in a Wii video game earning points, losing weight, and experiencing other virtual rewards as she engages in real world physical exercise. She could also see her model experience social support through virtual coaches or other influential people, such as family and friends. The video game could track her long term progress to help her achieve weight loss goals.

In summary, these studies have examined the social cognitive constructs of vicarious reinforcement and identification in a novel way. Rather than striving to find a universal model that matches an observer on some characteristics but cannot match on others, or finding a model that only appeals to certain observers, new technologies enable us to create an individually tailored model: the self. Such a potent tool could have several everyday applications, such as appearing in a video game to encourage physical activity in children or on a cell phone reminding a traveler to squeeze in a workout at the hotel gym. Operating within the framework of social cognitive theory, IVET and other new technologies have great potential as behavioral therapies to help people attain their health goals.

NOTES

1. An initial sample of $N = 97$ was obtained. Due to a technological failure, some participants' data did not record in two conditions. A random sample was taken from the unaffected condition to balance the number of participants in each condition, leaving a final sample of $N = 63$. The statistical models perform similarly with or without the extra participants.
2. Due to a floor effect in the Other condition, the equal variance assumption of ANOVA was not met. Inferential tests were rerun adjusting for this violation, and the result was still significant.
3. During the experiment and in the follow-up questionnaire, participants completed a self report measure of arousal, the short version of the Activation-Deactivation Arousal Checklist (ADACL; Thayer, 1989). No significant differences were found; this measure is not discussed further.
4. Sex was examined as a factor in each study, and there were no significant differences between men and women in any analysis.

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APPENDIX: SURVEY ITEMS

Paffenbarger Physical Activity Questionnaire Items (Study 3)

These items were extracted from the PPAQ. Examples of MET activity levels were borrowed from Aadahl and Jorgensen (2003).

Please take a moment to think about where you have been and what you have done in the last 24 hours since you participated in the experiment. The following questions will ask you about your activities during this time period and how typical these activities are. Complete the chart below to indicate how much time you spent engaging in the following activities. The chart should total 24 hours.

1. Sleep, rest
2. Sitting quietly, watching television, listening to music, or reading
3. Working at a computer or desk, sitting in a meeting, eating
4. Standing, washing dishes or cooking, driving a car or truck
5. Light cleaning, sweeping floors, food shopping with grocery cart, slow dancing or walking down stairs
6. Bicycling to work or for pleasure, brisk walking, painting, or plastering
7. Gardening, carrying, loading or stacking wood, carrying light object upstairs
8. Aerobics, health club exercise, chopping wood or shoveling snow
9. More effort than previous level: running, racing on bicycle, playing soccer, handball, or tennis

In the last day, approximately how many city blocks (or miles) did you walk? (12 blocks is approximately 1 mile.)

In the last 24 hours, approximately how many flights of stairs did you climb? (A flight of stairs is 10 stairs.)