THE USE OF VIRTUAL SELF MODELS TO PROMOTE SELF-EFFICACY AND PHYSICAL ACTIVITY PERFORMANCE

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CHAPTER ONE: INTRODUCTION

Research in the health domain provides strong support for the role of self-efficacy in the adoption and maintenance of healthy behaviors. *Self-efficacy* is an individual's perceived ability to enact a behavior and attain anticipated outcomes (Bandura, 1977, 1997). If a person feels that he or she can perform a behavior, he or she is more likely to do it. For example, if a man feels it is impossible for him to lose weight, he is unlikely to make an effort to do so; however, if he feels he is capable, he is more likely to start a diet or exercise plan. Self-efficacy also helps an individual overcome perceived obstacles, setbacks, and other negative events that may discourage behavioral modeling. For example, if that same man loses some weight, but then regains a few pounds back, his self-efficacy may help him recover and stick to his initial weight loss goals. Previous studies have shown that self-efficacy plays a major role in smoking cessation, exercise adherence, dieting, and other forms of disease prevention and management.

Self-efficacy is a driving force in social cognitive theory, which suggests that people can learn behaviors vicariously through the observation of models (Bandura, 1977, 1986, 2001). Virtual environments (VEs) present the unique opportunity to create and manipulate photorealistic virtual humans, which can be designed to look remarkably similar to the self (Bailenson, Blascovich, & Guadagno, 2008). These virtual selves can behave in ways that the self does not, enabling them to serve as models to promote imitation of behaviors by the person in the physical world. My previous research has supported the utility of other components of social cognitive theory in the development of effective virtual models for diet and exercise. I have used virtual humans to demonstrate that *identification*, the extent to which an individual relates to and feels similar to a model, influences modeling behavior. I have manipulated virtual models to show *vicarious reinforcement*, specifically the rewards (weight loss) and punishments (weight gain) associated with exercise. My research has shown that virtual self-models, which provide high levels of identification, lead to greater modeling of the portrayed behavior, particularly those that demonstrate rewards and punishments. At this stage, further research is needed to determine the mechanisms behind this modeling, particularly the role of self-efficacy as it is considered such a fundamental aspect of health behavior change.

In light of my earlier work in virtual reality, another lingering question is whether these stimuli must be delivered in a virtual environment. Virtual environments can be costly, creating virtual scenes can be time-consuming, and the equipment can be cumbersome. Mental imagery, on the other hand, is a low cost and low investment method. Perspectives on cognitive effort, including cognitive load theory (Chandler & Sweller, 1991), indicate that these two stimuli may require different levels of cognitive processing capacity. Engaging in mental imagery is deemed a more effortful and cognitively demanding process than observing a visual stimulus, and may place participants at a higher risk for cognitive overload. Additional research shows that some people are not adept at visualizing; thus, mental imagery may not be a fruitful task for them. Given the constraints of each type of stimulus, it is important to determine if there is an advantage to either treatment in promoting health behaviors.

Because of the obesity epidemic and the continuous rise in death rates for heart disease and preventable forms of cancer, many scientists have devoted their research efforts to developing mass media campaigns and other mediated treatments to inform the public and effect changes in health behavior. Traditional media campaigns are limited however in their ability to deliver a specific, personalized, and impactful message to an individual. Immersive virtual environments present the opportunity to create uniquely tailored, interactive, rich, and engaging health messages. Considering the importance of health on an individual and social level as well as the growing opportunities provided by the diffusion of new media technologies, the affordances of VEs and their utility in the delivery of health information merits further research. The studies of this dissertation project extend this line of inquiry by considering the role of virtual and imagined self-models in changing individuals' health beliefs and behaviors. This dissertation will 1) explain the role of self-efficacy within the context of social cognitive theory; 2) review previous research on modeling health behaviors across media; 3) discuss virtual self representations as well as theoretical frameworks that inform and describe their use; 4) consider the attributes and affordances of immersive virtual environments; 5) describe the pretests that inform the current studies; and 6) present two new studies designed to shed more light on our understanding of virtual behavioral modeling.

CHAPTER TWO: SOCIAL COGNITIVE THEORY

Social cognitive theory (SCT), originally known as social learning theory, was derived from behaviorism. Bandura (1977) challenged many of the primary assertions of behaviorism, particularly the stimulus-response model of human behavior that suggested "a one-way control process which reduces individuals to passive respondents to the vagaries of whatever influences impinge upon them" (p. 6). Humans, Bandura argued, are more complex creatures, capable of reasoning and individual creative response. Regarding this human agency, Bandura (2001) noted that people are "self-organizing, proactive, self-reflecting, and self-regulating, not just reactive organisms shaped and shepherded by environmental events or inner forces" (p. 266). Thus, social learning involves active, agentic participation in cognitive decisions and the behaviors that result (Bandura, 1989).

Because of this conceptualization, Bandura (1977) also rejected the one-way flow of stimulus-response models. Instead, he posited that personal determinants, behavioral determinants, and environmental determinants interacted and exerted mutual influence over each other, and that this *triadic reciprocal determinism* served as a better predictor of human behavior (Bandura, 1986). These factors are not necessarily balanced, nor do they necessarily occur at the same time. In a given instance, any one may serve as the dominant factor and override the effects of the others. Regardless, it is these three factors that determine the viability of social learning taking place.

According to SCT, the observation of modeling is a learning process from which the observer gleans information about the modeled behavior. That information is processed in a symbolic manner and then stored for future use. Four processes are needed for observational learning to occur. *Attention* is the ability of the individual to perceive the behavior, including the individual's sensory capacities and perceptual sets; relevant traits of the observed behavior such as functional value, salience, and complexity; and the attractiveness and distinctiveness of the model (Bandura, 1977). *Retention*, or the ability to create mental symbolic representations for future recall, involves remembering both verbal coding and mental images pertaining to the behavior. This allows the individual to cognitively organize the information for future access as well as mentally rehearse the behavior. *Motor reproduction*, on the other hand, involves the physical enactment of observed behaviors. Finally, *motivation* is essential; through external, vicarious, and self-reinforcement, the individual determines whether to enact or avoid the learned behavior (Bandura, 1977). These four processes determine what symbolic representations will exist regarding the referent behavior and what information will guide decision-making regarding enactment.

The subsequent imitation of these learned behaviors is contingent on four factors. *Identification* refers to the extent to which an individual relates to a model and feels that s/he is similar to the model (Bandura, 1977; Bandura & Huston, 1961). *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 (Bandura, 1977; Bandura, Ross, & Ross, 1963). Observing this reinforcement helps the observer develop *outcome expectancies*, or beliefs in the likelihood of the behavior yielding particular outcomes (Bandura, 1977). Another essential component of SCT is *self-efficacy*, the individual's perceived ability to enact a behavior and attain anticipated outcomes (Bandura, 1977, 1982, 1997). The belief that one is capable of fulfilling one's goals (i.e., successful imitation) is crucial in determining whether or not one will attempt to mimic the behavior. Each of these components will be reviewed individually.

Identification

Identification refers to the extent to which an individual relates to a model and feels that s/he is similar to the model. Kelman (1961) originally recognized identification as one of three processes of social influence. Identification has been shown to increase the likelihood of performing learned behaviors (Bandura & Huston, 1961; Bandura, 2001; Schunk, 1987). 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; Bussey & Perry, 1982; Kazdin, 1974), age (Kazdin, 1974; Schunk & Hanson, 1985), race/ethnicity (Anderson & McMillion, 1995; Kalichman, Kelly, Hunter, Murphy, & Tyler, 1993) or skill level (Meichenbaum, 1971), as well as when models demonstrate similar opinions (Hilmert, Kulik, & Christenfeld, 2006), backgrounds (Rosekrans, 1967), or previous behaviors (Andsager et al., 2006).

Degree of identification with a model has also been shown as an important factor in ascertaining the differential effects of media messages on individuals (Andsager, Austin, & Pinkleton, 2001; Basil, 1996; Cohen, 2001, 2002; Maccoby & Wilson, 1957). 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, 1999, 2002). Ito, Kalyanaraman, Brown, and Miller (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/ethnicity. It is likely the participants identified more highly with these guides, and the authors speculated that this may influence message effectiveness. Models matched on sex and ethnicity were more effective than nonmatched models in getting African-American women to get tested for HIV and request condoms (Kalichman et al., 1993); a subsequent study also revealed that African-American women who viewed a model matched on sex and ethnicity was more effective than a model matched solely on ethnicity in persuading them to get tested (Kalichman & Coley, 1995). A recent media campaign to encourage healthy eating and physical activity among New Orleans residents featured African-American actors speaking with a local accent in order to promote higher levels of identification among the target audience (Beaudoin, Fernandez, Wall, & Farley, 2007). Andsager et al. (2006) found that perceived similarity to a model in an anti-alcohol advertisement was positively related to the message's effectiveness.

Although these mass media messages can target narrower groups, they 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 that will be discussed in the following chapter present researchers with the opportunity to maximize identification with a model.

Vicarious Reinforcement

Bandura critiqued the behaviorist claim that learning necessitated direct experience. For example, if a child touched a hot stove, she would be burned and thus learn that a hot stove should be avoided in the future. Social cognitive theory argues that observational learning could also occur: a stimulus could be encountered by an observed other and yield a response. If the child observed another person touch a hot stove and get burned, she would learn to avoid the behavior without having to experience it firsthand. In addition, distal models of these consequences can be presented via media. This process of *vicarious reinforcement* is a significant advancement offered by SCT. 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 (Bandura et al., 1963; Bandura, 1965). For example, Bandura et al. (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. Bandura (1977) clarifies that such reinforcement is not necessarily an automatic stimulus; rather, reinforcement "serves principally as an informative and motivational operation rather than as a mechanical response strengthener" (p. 21). Vicarious reinforcement is effective because it relies on the ability of observers to role play by envisioning a model's behaviors—and the consequences thereof—as their own.

Outcome Expectancies

Based on this process, an individual develops *outcome expectancies*, or beliefs in the likelihood of a certain behavior yielding particular outcomes (Bandura, 1977). If modeled behavior consistently results in rewards, then observers will expect the outcome of their own imitative behaviors to yield rewards. These rewards may create a *disinhibitory effect* that then encourages the behavior regardless of other social constraints. For example, although aggression is generally a socially unacceptable behavior, if an observer sees that it is rewarded, disinhibition will occur and he or she will likely imitate it. Conversely, if a model is punished for a behavior, observers will anticipate that if they enact the behavior, they too will be punished. This typically produces an *inhibitory effect*, in which the threat of punishment discourages a behavior. Bandura (1977) found that if a behavior has anticipated consequences, a lack of reward will serve as positive reinforcement if punishment is expected and as punishment if a reward is expected. Hence, if a child breaks a known rule and is not punished, this nonreward will still serve to positively reinforce the rule-breaking behavior. If the child performs a good deed in anticipation of a reward and is not rewarded, the child will react as if this were a punishment and be deterred from performing the good deed in the future.

Self-Efficacy

Bandura (1977, 2006) claimed that humans are agentic and self-reflective beings, and thus the likelihood of behavior imitation is contingent on self-perception. *Self-efficacy* is an individual's perceived ability to enact a behavior and to attain anticipated outcomes (Bandura, 1977). If an individual does not feel capable of imitating a modeled behavior or achieving the observable outcome, he or she is less likely to attempt the behavior. Self-efficacy beliefs are distinct from outcome expectancies; self-efficacy is comprised of beliefs regarding the individual and the behavior, whereas outcome expectancies delineate beliefs regarding the behavior and the outcome without consideration of the individual. To clarify, an individual may be motivated to imitate a behavior after observing the model's reward for this performance. The individual has an expectation that the behavior will yield a certain outcome. However, a motivated individual must also assess his or her own likelihood to be able to achieve that outcome; thus, one's self-efficacy beliefs determine whether or not the outcome expectancy holds and, as a result, whether or not the modeled behavior is imitated (Maibach & Murphy, 1995). Additionally, self-efficacy can both affect behavior and be affected by behavior. For example, if a volleyball player feels he is able to perform a jump serve and successfully jump serves on several occasions, his success in that behavior will enhance his feelings of self-efficacy and increase the likelihood that he will jump serve in the future.

Although there are many misconceptions in the literature, it is important to note that self-efficacy is not a universal, unwavering belief or personality trait (Bandura, 1997, 2007). Rather, self-efficacy beliefs are specific to a particular behavior and can vary according to contextual factors. As Bandura and Schunk (1981) stated, "judgments of self-efficacy are not simply reflectors of past performance…rather they reflect an inferential process in which the self-ability inferences drawn from one's performances vary, depending on how much weight is placed on personal and situational factors that can affect how well one performs" (p. 596). Thus, measurement of self-efficacy must be specifically cultivated to the context and behavior.

Operationalization and Measurement of Self-Efficacy

Because of misperceptions about the construct, many measures of self-efficacy are too broad or incomplete to be useful to research in the tradition of social cognitive theory (Bandura, 2007; Maibach & Murphy, 1995). Bandura (1986) suggested that effective measurement of the construct should take into consideration level, strength, and generality. The *level* of self-efficacy is determined by whether or not someone feels that s/he can perform a given action, and if so, at what degree of difficulty. Perceived self-efficacy is also measured on the *strength* of the belief, or how certain the individual is that s/he can perform the behavior. Finally, self-efficacy beliefs are evaluated on their *generality*, or the scope of application either within a single behavioral domain or across domains. Bandura (2004) also noted that a measurement instrument should include questions that specifically address the impediments that may hinder an individual's self-efficacy (e.g., a mood state or an environmental issue like bad weather). Considering all these facets ensures the utility and validity of the measurement and enables comparisons to other relevant research.

Factors Determining Self-Efficacy

Bandura (1977, 1997) identified several mechanisms that may influence perceived self-efficacy. *Performance accomplishments* or *mastery experience* are based on one's own past efforts; if an individual has previously succeeded at a related task, self-efficacy may be higher than if failure occurred. Thus, one's history with a specific behavior as well as with related behaviors may come into play. For example, if a former tennis player decides she wants to take the sport up again, she may recall her previous successes and feel she is physically capable of returning to the court. Alternatively, an inexperienced athlete may decide he wants to take up tennis, but is hindered by the fact that the last time he tried to take up a new sport, he did not succeed. *Physiological and psychological feedback*, often affective in nature, may also impact self-efficacy. High levels of arousal may create a level of action readiness that promotes feelings of self-efficacy; in contrast, one could have such a strong negative affective response, such as stress or anxiety, that one feels less able to perform the behavior. (Bandura & Rosenthal, 1966; Thayer, 1989). Based on the negative impact of such emotions on self-efficacy, Bandura (2001, 2002) argues that fear appeals are not effective stimuli for promoting health behavior change (for a contrary opinion, see Witte & Allen, 2000).

Persuasive efforts from others may also boost or detract from self-efficacy (Bandura, 1977). A parent might offer encouragement to his child when she struggles with her homework, promoting her sense of self-efficacy. Or, a basketball player might deride and insult her opponent and convince him that he is incapable of shooting a free throw. *Vicarious experience* can also enhance or diminish self-efficacy; by seeing others perform the behavior successfully, individuals are more likely to assume they can do the same. *Situational circumstances*, including variations in personal and environmental factors, may play a role; for example, a vocalist might feel confident practicing with her band in her garage, but if anyone drops in to listen, she might lose her confidence. Bandura and Schunk (1981) found that *proximal goal-setting*, as opposed to making distal goals or no goals, promoted students' self-efficacy and intrinsic interest in a subject that previously did not interest them. Self-efficacy may also be affected by the level of *identification* with an observed model (Bandura, 1997). If a heavyset woman cannot identify with the size-2 model promoting the newest fad diet, she may feel that she cannot possibly lose weight on that diet. In contrast, if the model looks very similar to the self, it is possible that this may promote greater feelings of self-efficacy. Peng (2008) found that greater identification with a video game character in a health-promoting video game led to greater self-efficacy regarding dietary behaviors.

Outcomes of Self-Efficacy

Bandura (1986) identified several consequences of perceived self-efficacy. First, it creates *thought patterns* or beliefs. The individual sets goals in accordance to perceived ability, and people with a higher sense of self-efficacy are more likely to set higher goals for themselves (Bandura, 1989). These higher goals may become a self-fulfilling prophesy and result in greater achievement. Second, self-efficacy beliefs have notable *emotional effects*. People with low self-efficacy are susceptible to stress and depression (Bandura, 1986). Third, self-efficacy directly impacts an individual's *effort*. People with a greater sense of self-efficacy are willing to expend more effort during goal attainment (Bandura & Cervone, 1983). Finally, self-efficacy promotes *persistence*. People with higher self-efficacy are more likely to stay motivated and maintain behaviors, even in the face of adversity. They also recover more quickly from setbacks (Bandura, 1989). These factors all play a role in health behavior maintenance via self-regulation.

Health Self-Efficacy

In the realm of health, self-efficacy is often cited as one of the primary causal variables in the study of health behaviors. As Bandura (2000) stated, "The stronger the instilled perceived self-efficacy, the more likely are people to enlist and sustain the effort needed to adopt and maintain health promoting behavior" (p. 304). Self-efficacy has been shown to play a role in physical activity adoption and maintenance (Anderson, Wojcik, Winett, & Williams, 2006; Garcia & King, 1991; Sallis et al., 1989; Sallis, Haskell, Fortmann, Vranizan, Taylor, & Solomon, 1986; Rovniak, Anderson, Winett, & Stephens, 2002), diet (Anderson, Winett, & Wojcik, 2007; Schwarzer & Renner, 2000), physical rehabilitation (Schwarzer, Luszczynska, Ziegelmann, Scholz, & Lippke, 2008); weight loss (Linde, Rothman, Baldwin, & Jeffery, 2006; Warziski, Sereika, Styn, Music, & Burke, 2008), contraception use (Forsyth & Carey, 1998; Wulfert & Wan, 1995), sun safety (Jackson & Aiken, 2006; Myers & Horswill, 2006), breast self-examinations (Garcia & Mann, 2003; Van Ryn, Lytle, & Kirscht, 1996), health information seeking (Kennedy, O'Leary, Beck, Pollard, & Simpson, 2004; Rains, 2008; Rimal, 2001a, 2001b), blood donation (Armitage & Conner, 2001), dental flossing (Schwarzer, Schüz, Ziegelmann, Lippke, Luszczynska, & Scholz, 2007), STD prevention (O'Leary, Jemmott, & Jemmott, 2008), AIDS prevention (Maibach & Flora, 1993), smoking cessation (Gwaltney, Metrik, Kahler, & Shiffman, 2009), drug and alcohol rehabilitation (Hyde, Hankins, Deale, & Marteau, 2008), health behaviors during pregnancy (Moore, Turner, Park, & Adler, 1996), seat belt use (Schwarzer et al., 2007), and disease management (Clark & Dodge, 1999).

Some consistent effects have been shown for the role of self-efficacy in behavior change; however, these are often limited to a certain domain (e.g., exercise or smoking) and other models may be appropriate for other topics (Clark & Dodge, 1999; Van Ryn et al., 1996). Self-efficacy has been shown in many studies to have direct effects on behavior and also to serve a mediating role between other variables or types of treatment and behavior outcomes. Rimal (2000) found that self-efficacy mediates the relationship between knowledge about healthy behaviors and the performance of those behaviors.

Self-efficacy often mediates the relationship between the individual's outcome expectancies and performance of the behavior (Schwarzer et al., 2007). In tests of the theory of planned behavior, self-efficacy has been shown to affect behavioral intentions and action (Rimal, 2001b; Van Ryn et al., 1996), sometimes playing a mediating role between the two (Schwarzer et al., 2008). People with higher levels of self-efficacy are more likely to enact health behavior changes than those with lower self-efficacy (Bandura, 1998; Strecher, DeVellis, Becker, & Rosenstock, 1986). Those with high self-efficacy are also more likely to maintain exercise behaviors after their adoption (Sallis et al., 1986; Garcia & King, 1991). Rimal (2001a) identified a mutual reinforcement model: prior self-efficacy and knowledge predicted subsequent exercise behavior, and prior exercise behavior predicted subsequent self-efficacy and knowledge.

Within the health context, researchers have attempted to integrate existing health behavior stage-of-change theories with the construct of self-efficacy to identify temporal and event-based fluctuations (Marlatt, Baer, & Quigley, 1995; Wallace, Buckworth, Kirby, & Sherman, 2000). For example, Schwarzer (1992, 1999) proposed the health action process approach (HAPA), a model of self-regulation that distinguishes between an initial motivation phase, in which the intention to act is developed, and the volition phase, in which actions, persistence, and possible failure and recovery take place. Based on these two phases, Schwarzer distinguished between *action self-efficacy* (beliefs that exist in the motivation phase, before behavior is enacted) and *coping* or *recovery self-efficacy* (beliefs that exist once the behavior has transpired, and maintenance is desired). Schwarzer and Renner (2000) found that action self-efficacy predicted intentions during a pretest assessment, and coping self-efficacy mediated the relationship between outcome expectancies and behavior at posttest. Identifying these nuances in the construct may help explain some of the disparate findings regarding the role of self-efficacy in health behavior change.

CHAPTER THREE: TRADITIONAL MASS MEDIA HEALTH CAMPAIGNS

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 drug abuse by showing models punished with appalling physical symptoms or harmed social relationships (Witte & Allen, 2000). Entertainment-education efforts rooted in the principles of SCT often portray the rewards and punishments associated with health behaviors through plot lines in television and radio shows (Brown & Cody, 1991; Papa et al., 2000; Rogers, Vaughan, Swalehe, Rao, Svenkerud, & Sood, 1999; Singhal & Rogers, 1999, 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, Murphy, Huang, Gusek, Greene, & Beck, 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 were more likely to get their blood pressure checked.

Meyerowitz and Chaiken (1987) considered four ways that health messages could affect health habits, including fear arousal, promotion of perceived vulnerability, information transmission, and promotion of self-efficacy. They discovered that health messages were effective in changing behaviors when they boosted the individual's sense of self-efficacy. A well-developed media campaign should thus consider how its content and delivery can best promote self-efficacy and self-regulation so that health behavior change can endure.

Despite considerable theoretical speculation in the literature, mass media health campaigns are not always rooted within solid theoretical predictions; instead, they are developed like product advertising campaigns, relying on aesthetics, heuristics, and other tricks of the trade that are effective for branding but not necessarily successful health interventions. This may explain why so many of them fail to change audience behaviors (Fishbein & Cappella, 2006; Flora & Thoresen, 1988). More recently, these efforts have been entrusted to communication and social psychology scholars to ensure that efforts are grounded in persuasive theories. Implementing the appropriate variables, several campaigns have reported significant changes in health-related cognitions, attitudes, and behaviors. The Stanford Five-City Multifactor Risk Reduction Project entailed a multiyear media intervention with several assessments comparing control and treatment cities on various health behaviors (Farquhar et al., 1985, 1990; Rimal, Flora, & Schooler, 1999; Schooler, Chaffee, Flora, & Roser, 1998; Schooler, Flora, & Farquhar, 1993; Schooler, Sundar, & Flora, 1996). Several forms of media were implemented, including printed tip sheets and booklets, a newspaper column, television shows, and televised public service announcements. Findings included that once awareness was piqued via media exposure, more health information-rich media were sought (Schooler et al., 1993). Also, media exposure led to interpersonal discussion and information seeking. The resultant knowledge and social support, in turn, promoted self-efficacy and behavioral change (Rimal et al., 1999; Schooler et al., 1993).

Other mass media health campaigns have also achieved some success. People exposed to the BBC's "Fighting Fat, Fighting Fit" campaign reported significant weight loss, less fat intake, and less snacking, as well as increases in exercise and fruit and vegetable consumption over the course of the campaign (Miles, Rapoport, Wardle, Afuape, & Duman, 2001). Renger, Steinfelt, and Lazarus (2002) targeted a population using local participants and scenery in a PSA campaign to promote physical activity. They found that the media campaign caused changes in viewers' perceptions of benefits and barriers to physical activity as well as bolstering their self-efficacy and yielding an increase in exercise behavior. Beaudoin et al. (2007) adopted similar targeting tactics to accommodate an African-American population in New Orleans, and over five months the campaign succeeded in improving attitudes toward a healthy diet and promoting more walking behavior. In contrast to the success of these campaigns, Marcus, Owen, Forsyth, Cavill, and Fridinger (1998) reviewed 28 media-based physical activity interventions and found that they had very little impact on physical activity. Thus, although some campaigns stand out as successful, it seems that in the grand scope, only a fraction of them are achieving the desired effects.

CHAPTER FOUR: HEALTH BEHAVIOR CHANGE USING NEW MEDIA TECHNOLOGIES

New technologies have the potential for many advances over traditional mass media campaigns. Schooler et al. (1998) evaluated traditional health communication campaign media on their key factors: *reach*, or how broad an audience they could achieve; *specificity*, or how detailed and individualized the information could be; and *impact*, or how effective the message was in yielding actual behavioral change. They found that tip sheets, booklets, television programs, newspapers, and television public service announcements all suffered from "tradeoffs"—that is, no one channel was able to reach a great number of people, present a specific, targeted message, and successfully change health behaviors.

Evolving computer-based media have the potential to overcome these limitations. The use of the Internet and computer-generated interventions is often less expensive, faster in both the creation and delivery of messages, and able to reach larger numbers of people (Napolitano & Marcus, 2002). Rather than pushing a generic message to the broadest possible audience, messages can be effectively and efficiently *targeted* and *tailored* to cater to the individual's needs (Kreuter & Strecher, 1996; Kreuter, Strecher, & Glassman, 1999). King, Ahn, Atienza, and Kraemer (2008) define *targeting* as "the systematic matching of subpopulations of individuals to specific interventions based on the characteristics of the subpopulation," whereas *tailoring* is "adapting a particular intervention that individuals are receiving to the specific needs of the individual" (p. 252). A campaign may be targeted towards a certain group (e.g., teenagers) and distributed uniformly (e.g., through an advertisement that is designed specifically for adolescents). Tailoring would require more specific information about an individual's relevant health behaviors or his or her reactions to a particular intervention. Traditional media efforts have been successful at targeting populations, but the interactivity of new media is almost necessary to effectively tailor a mass health intervention.

Computer-Based Message Tailoring

Despite some successes, traditional mass media campaigns are hindered in their ability to create appropriate stimuli for the individual. A recent focus of public health interventions has been on the notion of tailoring mass media messages to create individual-specific treatments (Bock, Marcus, Pinto, & Forsyth, 2001; Hawkins, Kreuter, Resnicow, Fishbein, & Dijkstra, 2008; Napolitano & Marcus, 2002; Noar, Benac, & Harris, 2007; Winett, Tate, Anderson, Wojcik, & Winett, 2005). Kreuter and Strecher (1996) delivered tailored messages regarding health risks and found that tailored messages were 18% more effective than nontailored communication in getting recipients to change a risky health behavior. Campbell, DeVellis, Strecher, Ammerman, DeVellis, and Sandler (1994) administered computer-generated tailored dietary information, nontailored dietary information, or no information to a sample of adults. Those who received the tailored intervention decreased their total fat by 23%, whereas the nontailored group decreased intake by 9% and the control group by 3%. Marcus, Bock, Pinto, Forsyth, Roberts, and Traficante (1998) and Bock et al. (2001) used individual assessments of motivational readiness, self-efficacy, and current health behaviors to craft tailored messages about increasing physical activity. After six months, those who received tailored messages were engaging in significantly more exercise than those who received a generic intervention.

Bandura (2004) suggests that interactive tailoring is the greatest strength of new media. Computer-based feedback can be specified to accommodate the individual's motivations, current self-efficacy levels, unique obstacles and setbacks, and progress towards goals. DeBusk et al. (1994) developed the self-management model, enabling users to monitor and self-regulate their health behaviors through the use of an interactive computer system. First, goals, risk factors, obstacles, and motivations are identified and integrated into the individual's recommended treatment plan. As they follow the tailored advice, their progress is tracked, and users receive regular feedback on the effectiveness of their actions. This continuous monitoring and feedback encourages self-regulatory behaviors that support the desired health behavior change (DeBusk et al., 1994).

Indeed, because of the possibilities of interactivity and engagement with computer-based messages (Bucy & Tao, 2007; Sundar, 2007), it is likely that they also have the potential for greater impact (Goran & Reynolds, 2005). Interactive systems may also promote greater adherence to long-term interventions as the opportunity for feedback keeps the user invested and involved (Baranowski et al., 2003). With these capabilities, it appears that Internet-based applications may resolve many issues associated with traditional media.

Mobile Technologies

Extensive research has been conducted regarding the use of computer-generated, phone-delivered health interventions to promote healthful behaviors (e.g., King et al., 2007). Recent research has expanded this notion by using mobile devices to communicate health messages. King, Ahn, Oliveira, Atienza, Castro, and Gardner (2008) provided a group of over-50 adults with personal data assistants (PDAs) that helped monitor participants' physical activity levels over eight weeks. Following Bandura, self-regulation was promoted through the provision of individualized feedback every day and weekly goal-setting. Despite the sample's relative inexperience with PDAs, the devices were effective at promoting exercise: those who received the intervention reported greater caloric expenditure and more time engaging in moderate or vigorous physical activity than the control group. A related study used a similar design and sample to ascertain the effectiveness of PDAs for enhancing dietary choices (Atienza, King, Oliviera, Ahn, & Gardner, 2008). Participants who were equipped with PDAs showed an increase in vegetable intake over the treatment period, whereas those in the control group did not. Future studies will undoubtedly continue to explore the utility of mobile devices in delivering health messages, perhaps incorporating some of the content that will be discussed next.

CHAPTER FIVE: VIRTUAL HUMANS AND VIRTUAL SELVES

Representations of interactants in virtual environments can vary from a high fidelity virtual human to an anthropomorphized animal in an online role-playing game (see Nowak & Rauh, 2006, for a review), and this representation can have effects on both the user and observers (Castronova, 2004, 2005; Yee & Bailenson, 2007; Yee, Bailenson, & Ducheneaut, 2009). When virtual representations resemble the human form, users often treat them similarly to how they treat real people (Bailenson, Blascovich, Beall, & Loomis, 2003; Garau, Slater, Pertaub, & Razzaque, 2005). Beyond their appearance, these representations are distinguished by who or what controls their actions. *Avatars* are controlled by a human user, whereas *agents* are controlled by an algorithm (Bailenson & Blascovich, 2004). When a virtual representation is controlled by an algorithm, it is referred to as an *embodied agent* (Cassell, 2000). Users distinguish between representations that are controlled by humans as opposed to those controlled by agents; in general, if users believe they are interacting with an avatar rather than an agent, they are more persuaded and learn more (Hoyt, Blascovich, & Swinth, 2003; Okita, Bailenson, & Schwartz, 2008).

Recent scholarship has focused on the use of virtual humans as persuasive agents. Gilliath, McCall, Shaver, and Blascovich (2008) found that people experience feelings of identification with and empathy toward virtual humans which may increase their effectiveness as models and persuasive agents. Guadagno, Blascovich, Bailenson, and McCall (2007) also noted that certain characteristics of the virtual human (in this study, matching to the participant’s sex) enhance its ability to persuade. Traditional social facilitation effects have also been found with the use of virtual humans. Several scholars have found that when people are in the presence of a virtual human, their performance on easy tasks is enhanced, but performance of difficult tasks is hindered compared to being alone (Hoyt et al., 2003; Park & Catrambone, 2007; Zanbaka, Ulinski, Goolkasian, & Hodges, 2007).

Some studies have examined the role of persuasive agents specifically in health-related contexts. Ijsselsteijn, de Kort, Westerink, de Jager, and Bonants (2006) rendered a coach within a virtual cycling environment and found that her presence led participants to place a greater value on exercise and experience less tension and pressure, although she had no effect on actual performance. Ito et al. (2008) found that participants relied on self-similar avatars to guide them through information about sexually transmitted infections. Skalski and Tamborini (2007) found that interactive agents were successful in encouraging health message processing as well as promoting more positive attitudes towards healthy blood pressure and reporting the intention to get one's blood pressure checked. Bickmore, Gruber, and Picard (2005) found that interacting with a health-promoting virtual agent over time led to more health-related information seeking. As Bandura (1997) noted, persuasive messages from interpersonal sources can have a direct impact on self-efficacy. Additionally, the self-efficacy effects of media messages are often mediated by interpersonal means (Bandura, 2001). Using virtual humans to convey these messages may maximize the impact of mediated messages because they evoke many of the same feelings as interpersonal interactions.

Virtual Representations of the Self

Virtual representations of the self (VRSs) can also be powerful at evoking attitude and behavioral changes. Avatars are often the method by which users can extend the self into a virtual environment. Users are able to achieve goals such as social interaction, task accomplishment, navigation, or game participation using their avatars. Because of the flexibility of virtual environments, avatars allow users to experiment with their self-representations, giving them the opportunity to selectively present features of their "real" selves or experiment with different identities (Nakamura, 2002; Suler, 2002, 2004; Taylor, 2002; Turkle, 1995; Walther, 1996, 2007; Yee, 2006). They can adopt a different sex, gender, or sexuality; a different class or occupation; a different race or ethnicity; or a different height, weight, or level of attractiveness. Users may be embodied in these avatars for days, weeks, or even years in digital environments. Thus, it is unsurprising that people report having strong feelings toward or experiences with their avatars (Lewis, Weber, & Bowman, 2008).

Theoretical Explanations for the Effects of Virtual Selves

Relationships with virtual selves can be explored using a variety of frameworks from the social psychological literature. Generally, these explanations consider 1) how we choose to present ourselves and why; 2) how these presentations shape our sense of self; and 3) how this identity shift alters our beliefs, attitudes, and behaviors both within and outside of virtual environments.

Goffman's (1959) classic work integrated psychological and social understandings of identity to consider how the individual interprets and presents oneself in a social world. His dramaturgical notions of the front stage and back stage are particularly relevant to how people choose to present themselves in virtual worlds. Goffman claimed the front stage was where one performed one's identity, and the back stage was where one could strip away the roles and performance and essentially be one's “true” self. Because of the anonymity of online interactions, virtual environments present the opportunity for those who are uncomfortable or unsatisfied with their front stage lives to enact more aspects of their back stage selves.

Turkle (1995) suggests that the self is inherently fragmented, and that we can explore the different parts of ourselves through alternative presentations and role play online. Thus, beyond the expression of identity, virtual self representations may also represent a new method of self-realization. By creating a virtual self, it may be possible to become more attuned to one’s real world self. In the postmodern view, the self is not a unitary entity; rather, it is an amalgamation of multiple, fragmented selves. An avatar, or multiple avatars, presents an opportunity to embody these fragmented selves in a process of self-construction (Turkle, 1995).

This process of self-construction is not restricted to the “true” real world self, however. Markus and Nurius (1986) proposed the idea of *possible selves*, that is, cognitive constructions of the self that are based on past experiences, future hopes, and current goals and motivations. Our self-concept is not only what we are, but what we feel we could possibly be. Virtual representations can be used to embody our *wishful identification* selves (Hoffner, 1996; Hoffner & Buchanan, 2005), that is, the versions of ourselves that we wish we could achieve (Suler, 2004). Indeed, Bessiére, Seay, and Kiesler (2007) found that players’ avatars in *World of Warcraft* more closely resembled the idealized self than the real self. These wishful selves may also be projected into the real world. Konijn, Bijvank, and Bushman (2007) found that wishful identification with a video game character also carried over into real world interactions; the more adolescent boys wished they were like the violent video game character they played, the more aggressive behavior they demonstrated after game play.

How users are represented may impact identification, the bond users feel with these representations, and the resultant effects on users' sense of self. Current explorations of the concept of identification in the context of virtual worlds integrate the work of Kelman (1961), Bandura (1977, 2001), and Cohen (2001). Klimmt, Hefner, and Vorderer (2009) distinguish avatars (specifically those in video games) from other media characters because of the interactivity and control that the user has over an avatar that is not possible with a literary role or television character. Other conceptualizations of this dynamic have described it as *dyadic,* maintaining that there is an inherent separation between the observer and the observed character (e.g., transportation, Green & Brock, 2000; parasocial interaction, Horton & Wohl, 1956). Klimmt et al. argue that due to their interactivity and the user's control over the character, video games create a *monadic* relationship wherein "players do not perceive the game (main) character as a social entity distinct from themselves, but experience a merging of their own self and the game protagonist" (p. 354). The authors thus define identification as "a temporary alteration of media users' self-concept through adoption of perceived characteristics of a media person" (p. 356). They also argue that because of the active and responsive nature of this form of identification, it is most similar in concept to role playing.

Furthermore, Klimmt et al. (2009) proposed that identification is selective and temporally unstable. In virtual environments, characters may be far-reaching and fantastical, pushing the boundaries of reality. Thus, users select specific traits with which to identify. The consequences of these choices may explain differences in effects of video games. For example, if a character conquers a battlefield and slaughters a hundred enemies, a player might choose to identify with the character's courage, strength, power, aggression, and/or ruthlessness. The traits the user adopts during the process of identification may explain why some users experience increased feelings of aggression after such game play whereas others do not (Anderson & Bushman, 2001; Anderson & Dill, 2000; Anderson, Gentile, & Buckley, 2007). Indeed, some studies have found a link between identification with violent game characters and aggression (Konijn et al., 2007) and identification with characters leading to stereotyping and hostility (Eastin, Appiah, & Cicchrillo, 2009). Identification is also noted to be temporally unstable. While playing a game or immersed in a virtual world, the character might experience something that diminishes the user's experience of identification. For example, a character might make a choice the user disagrees with during a programmed narrative sequence, or the character might lose a battle and appear weak. Thus, identification is a fluid process that can be affected by many variables during an immersive experience and often impacts the effects of these experiences (Bessière et al., 2007; Hefner, Klimmt, & Vorderer, 2007; McDonald & Kim, 2001).

A related factor to the experience of identification is *self-presence*, or the experience of feeling one's self within a virtual environment (Lee, 2004; Ratan, Santa Cruz, & Vorderer, 2008; Ratan, 2010). Because one's physical body is not digitized and thus limited in its ability to extend into and integrate with a virtual environment, it is important to assess the degree to which people feel that they are able to interact as an intact self within the VE. User controls, tracking systems, and avatars all serve as tools to more naturally incorporate the self in the VE. Self-presence influences our experience of immersion and may have a direct effect on outcomes within the virtual environment (Ratan, 2010).

The degree to which we identify with or feel present within these avatars may also reflect or impact the degree to which we incorporate pieces of them in our offline selves. *Self-perception theory* (Bem, 1967, 1972) suggests that individuals infer their attitudes and traits through the self-reflective observation of their own behaviors. For example, if a woman spends a lot of time volunteering at a homeless shelter, she might infer that she is a compassionate, sympathetic person who helps people in need. Goldstein and Cialdini (2007) extended self-perception theory to incorporate modeled behaviors. They suggested that individuals may observe the freely chosen behaviors of someone to whom they feel close or have a “merged identity” with and then infer their own attributes, a process they labeled the *spyglass self*. For example, if the woman before observed her spouse volunteering at the shelter, she may determine that since she and her spouse are so similar, she is also charitably-minded, and this may increase her likelihood of also volunteering at the shelter.

Self-perception theory relates to virtual selves because people may observe their virtual self performing a behavior, and because they identify with and feel similar to the virtual self, they may infer their own attributes based on that behavior and increase the likelihood of them performing that behavior. Alternatively, they may observe the behaviors of another virtual person who appears similar to them and with whom they feel a merged identity, and the same effects may occur. An additional consideration should be weighed, however: Goldstein and Cialdini also argue that the observer must believe that the actions are a result of free choice. Due to the necessity of volition, it may be that if a virtual representation's behaviors are clearly programmed and/or attributed to an agent, the spyglass self effect does not occur, whereas if the behaviors are attributed to a human-controlled avatar, the effect occurs.

Yee and Bailenson (2007) specifically applied self-perception theory within virtual environments. The *Proteus effect* is hypothesized to occur when a user's virtual self-representation is modified in a meaningful way that is often dissimilar to the physical self. When the user then interacts with another person, the user's behavior conforms to the modified self-representation regardless of the true physical self or the other's impressions (Yee & Bailenson, 2007; Yee et al., 2009). For example, when participants embody attractive avatars, they behave like attractive people, disclosing more personal information and approaching another avatar more closely. When participants embody taller avatars, they are more confident in a negotiation task (Yee & Bailenson, 2007). Because virtual environments offer unlimited ways in which one can manipulate the virtual self, the Proteus effect may explain many offline outcomes of online interactions.

In sum, these perspectives provide many explanations for the potential effects of virtual self representations. Now, we will examine the different contexts in which we encounter virtual selves.

CHAPTER SIX: VIRTUAL ENVIRONMENTS

Immersive virtual environments (IVEs), or what is generally understood as virtual reality, enable researchers to investigate new mediated experiences and create novel experimental simulations (Lanier, 1992, 2001). IVEs are 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 (Loomis, Blascovich, & Beall, 1999; Blascovich, 2001, 2002; 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. Other sensory feedback may be provided, such as sound incorporated via headphones or speakers, or touch using a haptic device. Figure 1 illustrates the components of one type of IVE setup.

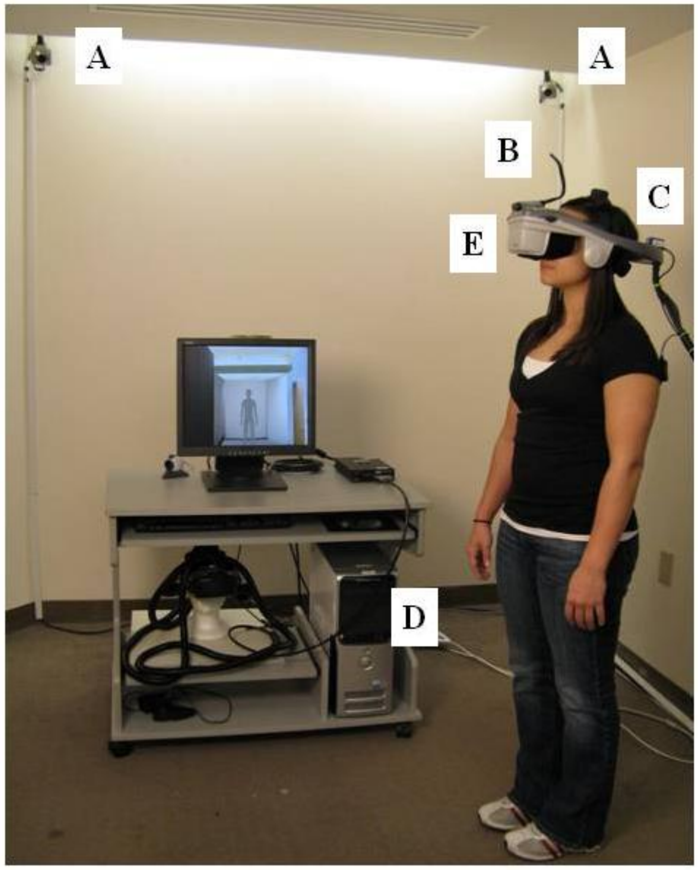

Figure 1. An immersive virtual environment setup. Cameras (A) in the corners of the room track an optical sensor (B) as the participant moves around the room. An accelerometer (C) gathers data on the participant's head movements. The data from these two tracking devices is sent to the computer (D) which uses that information to render the room appropriately in the head-mounted display (E).

IVEs have been used to replicate "real world" studies, by simulating lifelike environments and social interactions, as well as examine novel phenomena that are enabled only in the virtual world (Fox, Arena, & Bailenson, 2009; Loomis et al., 1999). IVEs have been used in a manner similar to traditional experimental environments to study psychological processes such as interpersonal distance (Bailenson et al., 2003), behavioral mimicry (Bailenson &Yee, 2005, 2007), leadership (Hoyt & Blascovich, 2007), social inhibition (Hoyt et al., 2003), obedience (Slater et al., 2006), prejudice (Dotsch & Wigboldus, 2008) and persuasion (Guadagno et al., 2007). Other studies have capitalized on the unique features of virtual environments to explore new affordances of the technology, such as the ability to embody avatars with various physical traits (Groom, Bailenson, & Nass, 2009; Yee & Bailenson, 2007; Yee et al., 2009); providing speakers the ability to make eye contact with multiple interactants at the same time (Bailenson, Beall, Loomis, Blascovich, & Turk, 2005); or optimizing the contextual factors of learning environments by giving every student the same perspective in a virtual classroom (Bailenson, Yee, Blascovich, Beall, Lundblad, & Jin, 2008). Here, a few distinguishing features of VEs will be reviewed.

Media Richness

Media richness refers to the sensory quality of a medium and how it is experienced by the user (Trevino, Lengel, & Daft, 1987). Daft, Lengel, and Trevino (1987) compared media and face-to-face interactions on four criteria: 1) immediate feedback; 2) transmission of multiple cues, such as nonverbal communication or graphics; 3) language variety; and 4) personal focus. More richness is generally associated with better outcomes (e.g., Cable & Yu, 2006; Scheck, Allmendinger, & Hamann, 2008; Timmerman & Kruepke, 2006) although other factors can impact the effectiveness of media rich environments (Rice, 1992). On the authors' range of high (face-to-face interaction) to low (nonpersonalized text-based communication), IVEs would be considered high on media richness, perhaps higher than any other form of mediated communication. IVEs have the capacity for immediate feedback and interactivity, as the user receives instant updating of the environment based on his or her physical movements; also, real-time communication involving multiple cues is possible via voice transmission, face-tracking to convey emotions, body movements tracked and rendered on avatars, and other technologies. These methods also enable a variety of language to be shared in IVEs as easily as it is in face-to-face communication. A virtual environment can be continuously tailored to the individual based on the data it receives (based on the participant's movements, physiology, or other information.) These characteristics demonstrate that IVEs rank high on media richness based on Daft et al.'s criteria.

Presence

This high level of media richness is likely to influence how an individual perceives and becomes engaged with a virtual environment. The experience of *presence* entails the user's feelings that the mediated environment is real and that the user's sensations and actions are responsive to the mediated world as opposed to the real, physical one (Biocca, Harms, & Burgoon, 2003; Lee, 2004; Lombard & Ditton, 1997; Loomis, 1992; Riva, Davide, & Ijsselsteijn, 2003; Slater & Steed, 2000; Steuer, 1992; Wirth et al., 2007; Witmer & Singer, 1998). The user experiences presence as "being there" or "losing oneself" in the mediated environment (Lombard & Ditton, 1997). Although presence has been examined in the context of other media such as television and books, because of the immersive nature of the virtual experience, it is of particular importance to VE researchers. 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 individual differences among users (Sacau, Laarni, & Hartmann, 2008).

The examination of presence is important as previous studies have shown that the subjective experience of presence can impact the effectiveness of virtual treatments

(Skalski & Tamborini, 2007; Villani, Riva, & Riva, 2007) and the degree to which these stimuli translate into real world behavior (Fox, Bailenson, & Binney, 2009; Persky & Blascovich, 2008; Price & Anderson, 2007). In a review of the research, Lee (2004) identified three different aspects of presence, including *physical, spatial,* or *environmental presence* (the feeling that you are in a particular virtual space; Lee, 2004), *social presence* (the feeling that another person is sharing the virtual space with you; Biocca et al., 2003), and *self-presence* (the experience of a virtual self-representation as an extension of the self; Ratan et al., 2008; Ratan, 2010).

Interactivity

Participants inside an IVE often describe the experience as “being in a movie.” Unlike a movie, however, an IVE is characterized by *interactivity*, which has been characterized as an influential feature in new media (Bucy & Tao, 2007; Kiousis, 2002; Leiner & Quiring, 2008; Liu & Shrum, 2003; Sundar, 2004, 2008; Vorderer, 2000). Interactivity has been defined as both the user’s perception that the medium is responding to the user’s actions (Leiner & Quiring, 2008; Steuer, 1992) as well as the medium’s technological capacity to actually respond (Lee, Park, & Jin, 2006). In an IVE, 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). 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.

CHAPTER SEVEN: VIRTUAL ENVIRONMENTS AND HEALTH

The ability to transform virtual environments makes them fruitful venues for health interventions and research. Historically, virtual health treatments have evolved from interactive CD-ROMs to specially designed video games, online virtual worlds, and immersive virtual environments. The following section reviews the usage of VEs as a tool for health behavior change.

Health-Oriented Video Games

Video games have been successfully implemented in the delivery of health messages (Baranowski et al., 2003; Baranowski, Buday, Thompson, & Baranowski, 2008; Lieberman, 1997; Peng, 2009). Lieberman (1997) reported that asthmatic children who played *Bronkie the Bronchiasaurus*, a game specifically designed to portray the self-management of asthma, had significant gains in knowledge about asthma and their perceived self-efficacy in managing their condition. Lieberman also found that knowledge and self-efficacy persisted one month after children last played the game. Baranowski and colleagues (2003) designed a video game to promote fruit and vegetable consumption among children. After treatment, children who had played the game reported consuming an additional serving of fruits and vegetables each day compared to their non-game playing peers.

Peng (2008) argues that unlike other forms of media, video games offer players the opportunity to become more engaged in the message via a *mediated enactive experience*, or interactive role-playing. According to social cognitive theory, *enactive experience*, in which the participant performs the behavior, is more effective in generating self-efficacy than mere passive observation. Peng extends the concept of enactive experience to entail the mediated version of playing a character in a game. Indeed, she found that playing a health-promoting video game led to a greater increase in self-efficacy than watching the game being played. Thus, involvement and interactivity with virtual environments may lead to greater gains than other media formats.

Other Health-Oriented Virtual Environments

Virtual environments have long been employed in a variety of medical contexts, particularly for training physicians. Virtual models of the human body have become popular interactive tools for teaching medical students, nurses, and doctors the basics of human anatomy as well as complicated surgical procedures (O'Toole et al., 1998; Spitzer & Ackerman, 2008; Thalmann & Thalmann, 1994). VEs have also been used to teach medical personnel communication and decision-making skills because they can portray a variety of situations, from a regular checkup to the chaos of an emergency room, that practitioners may face (de Leo et al., 2003; Johnsen et al., 2006; Kenny, Rizzo, Parsons, Gratch, & Swartout, 2007; Mantovani, Castelnuovo, Gaggioli, & Riva, 2003).

Because VEs proved to be useful in training medical personnel, soon they were being developed as treatments for patients. One of the most common applications of fully immersive virtual environments is virtual reality exposure therapy (VRET; Gregg & Tarrier, 2007; Parsons & Rizzo, 2008; Powers & Emmelkamp, 2008; Riva, 2002, 2005; Rothbaum, Hodges, & Kooper, 1997). Psychiatric researchers realized that IVEs presented the opportunity to recreate highly realistic representations of fear-inducing contexts to treat patients who suffer from a specific anxiety or phobias. In the virtual environment, patients are gradually introduced to the negative stimulus in a virtual setting until they become desensitized or are able to cope with their fear or anxiety. VRET has been used to treat acrophobia (the fear of heights; Coelho, Santos, Silvério, & Silva, 2006), agoraphobia (fear of open spaces; Botella et al., 2007), arachnophobia (fear of spiders; Cote & Bouchard, 2005); aviophobia (fear of flying; Rothbaum, Hodges, Smith, Lee, & Price, 2000); public speaking anxiety (Harris, Kemmerling, & North, 2002), panic disorder (Botella et al., 2007) and social phobia (Roy, Klinger, Legeron, Lauer, Chemin, & Nugues, 2003). In addition to phobias, VRET has also been employed in the successful treatment of combat-related post-traumatic stress disorder (PTSD; Reger & Gahm, 2008; Rothbaum, Ruef, Litz, Han, & Hodges, 2003).

In the medical context, VEs have been shown to be an effective distraction method for helping patients manage pain (Gold, Belmont, & Thomas, 2007; Hoffman, Patterson, Seibel, Slotani, Jewett-Leahy, & Sharar, 2008). Children exposed to an interactive distraction in an HMD as opposed to other forms of distraction significantly increased their pain tolerance and pain thresholds (Dahlquist, McKenna, Jones, Dillinger, Weiss, & Ackerman, 2007). These studies demonstrate the power of VEs and the experience of immersion, as users who were present in a virtual environment were actually able to block out unpleasantries of the physical environment.

VEs have also been explored as a tool for cognitive behavioral therapy. Researchers have found that virtual cues can be used to stimulate alcohol cravings (Cho et al., 2008) and nicotine cravings in cigarette smokers (Baumann & Sayette, 2006). Thus, it is expected that these stimuli may be used therapeutically to teach addicts to cope with craving-inducing cues in a variety of situations. VEs have also been used in studying patients with eating disorders by exposing them to high-anxiety environments such as a kitchen filled with fattening foods and examining patients' emotional reactions

(Gutiérrez-Maldonado, Ferrer-García, Caqueo-Urizar, & Letosa-Porta, 2006). Researchers expect that these environments will be incorporated in therapy in which patients learn to cope with anxiety-inducing situations in a healthy manner.

Physical Activity within Virtual Environments

Virtual reality has been used for over a decade as a tool for encouraging physical activity and performance (Nigg, 2003). Many of these studies have focused on the use of virtual environments to facilitate rehabilitation efforts (Schultheis & Rizzo, 2001; Sveistrup et al., 2003). VEs have two features that uniquely facilitate physical rehabilitation: the ability to capture and review one's physical behavior three-dimensionally, thus enabling a close and interactive examination of one's progress and failures, and the ability to see one's own avatar rendered in real time from a third-person point of view (Bailenson, Patel, Nielsen, Bajscy, Jung, & Kurillo, 2008). VEs have been used to help stroke victims regain a sense of balance while walking (Deutsch & Mirelman, 2007; Fung, Richards, Malouin, McFadyen, & LaMontagne, 2006), help children with cerebral palsy develop muscular coordination (Bryanton, Bossé, Brown, McLean, McCormick, & Sveistrup, 2006), and study how virtual environments can help the elderly restore coordination and balance after a fall, even in treacherous conditions (Nyberg et al., 2006; Sondell et al., 2005).

Other studies have focused on using VEs to encourage longer and more vigorous exercise sessions, thus increasing exertion and caloric burn. Annesi and Mazas (1997) studied exercise adherence, comparing a VE-enhanced bicycle with a regular exercise bicycle, and found that those exercising in the VE condition had a greater adherence. Chuang and colleagues (2003) also compared cycling in a regular or virtual environment and found that 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 as opposed to exercising in a real environment experienced less tiredness and reported more energy and enjoyment. Ijsselsteijn et al. (2006) compared a low and high immersion environment and found that the high immersion environment led to greater motivation. Van Schaik, Blake, Pernet, Spears, and Fencott (2008) created a virtual exercise game for older adults and found that participants underestimated the time spent exercising by 38%, indicating they were so engaged in the VE they lost track of time and continued to exercise. A potential explanation is offered by Huang, Tsai, Sung, Lin, and Chuang (2008), who performed an extensive analysis of heart rate data while participants exercised in a virtual environment and found that VR has physiological effects that may promote greater endurance for anaerobic activity. These studies have demonstrated that virtual environments can create compelling and effective environments for exercise-related stimuli.

CHAPTER EIGHT: MANIPULATING THEORETICAL CONSTRUCTS USING VIRTUAL TECHNOLOGIES

Collectively, these studies demonstrate that virtual reality can keep participants interested and motivated while exercising, potentially enhancing exertion, intensity, and adherence, but they did not explore health-based theoretical explanations for these effects. Social cognitive theory provides a useful framework for the development of virtual health 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. For example, it is simpler to have a virtual human depict a skill at multiple levels of proficiency as opposed to finding models ranging in their abilities from novice to expert.

One challenge in creating an effective stimulus is finding the model with the most similarity to the target. 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.

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. Virtual humans can portray the highest level of similarity, including the same sex and age, but also the same skill level or emotional state as the individual. Such similarities can help people develop feelings of identification with and empathy toward virtual humans (Gilliath et al., 2008; Gratch & Marsella, 2005), increasing their effectiveness as models and persuasive agents.

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 to perform 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 baseball player could model a home run swing, but this may hamper the individual's feelings of identification with the model because a Major League player is not maximally similar to the self.

Another issue is that it may not be possible to model particular consequences. 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. 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. Also, it is impossible to use the self as a model because one cannot be transported into the future to observe the potential outcomes. These issues may be resolved, however, with the incorporation of transformed social interaction.

Transformed Social Interaction

The unique nature of virtual environments also led to the discovery of new theoretical constructs. Virtual technologies enable us to modify interpersonal communication in novel ways that we could not achieve in the real world, resulting in *transformed social interaction* (TSI; Bailenson, Beall, Loomis, Blascovich, & Turk, 2004, 2005). According to Bailenson, Beall, Loomis, et al. (2004), TSI presents advantages over traditional forms of communication in three realms. First, TSI presents users with the opportunity to enhance their normal perceptual abilities (Bailenson & Beall, 2006). For example, participants might be able to see other participants' names, affiliations, or other relevant personal information hovering over their avatars. Participants can also view an environment from different points in the room through *multilateral perspective taking*. Second, VEs also enable manipulations of the context of the interaction including time and space (Bailenson & Beall, 2006); participants may choose to "rewind" a conversation to hear part of it again, or "pause" while they collect their thoughts. Third, and perhaps the most fruitful realm for TSI research, is controlling self-representation, namely "decoupling the rendered appearance of behaviors of avatars from the human driving the avatar" (Bailenson & Beall, 2006, p. 3). For example, *identity capture* entails obtaining the participant's image and using software to morph it with other individuals' images. Blending the two representations gives the other individual some of the more familiar features of the self; the resulting similarity and familiarity breeds more liking of this individual (Bailenson, Garland, Iyengar, & Yee, 2006).

One method of transforming the self-representation involves the use of a virtual human that is photorealistically similar to the physical self but behaves independently of the self. 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. Although this transference is not flawless, it creates relatively accurate models of the human form, and the striking similarity gives these virtual representations of the self (VRSs) great potential as stimuli in virtual realms. See Figure 2 for an example.

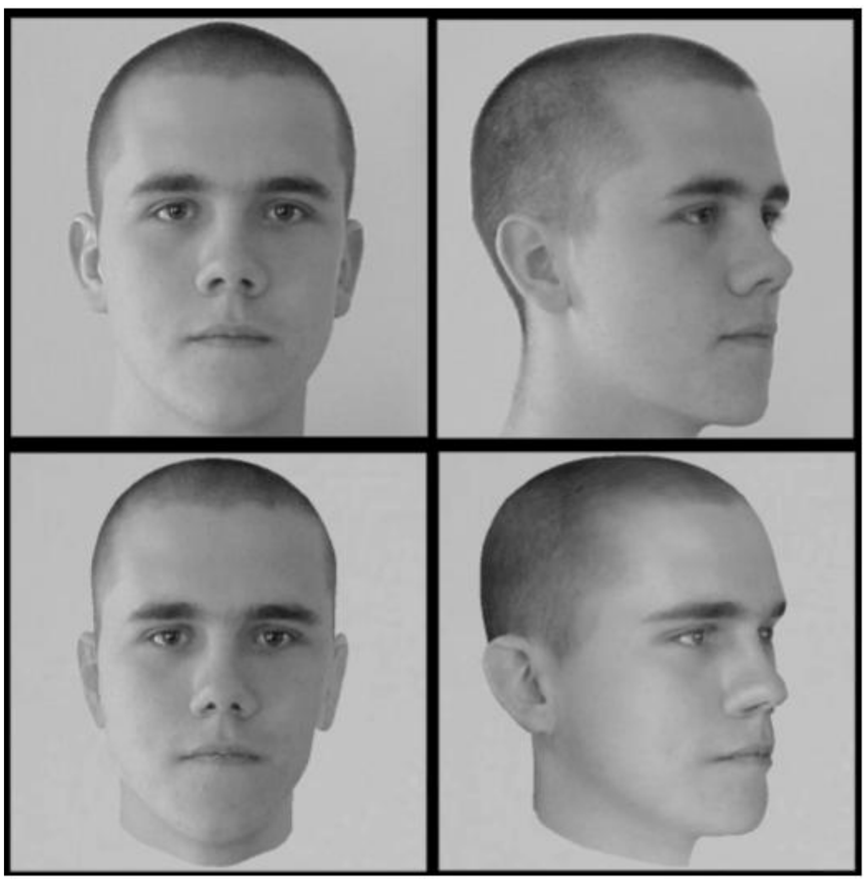

Figure 2. Constructing the virtual self. Photographs of an individual (top row) can be used to create a realistic virtual model of the individual's head (bottom row).

The use of a virtual representation of the self (VRS) as a model has many advantages over traditional modeling efforts. First, the VRS is maximally similar to the self, so issues of identification with a model are overcome. The VRS can be matched on any relevant quality to the real self. Second, compared to watching oneself on video, the VRS is capable of performing activities at a higher level of proficiency than the physical self, and the degree of skill can be modified as a continuous variable to present the optimal model for each stage of learning. Third, the VRS is also capable of transformation that the real self cannot easily achieve. 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. In sum, virtual representations of the self have unique affordances that may make them more potent and effective models than those used in traditional health behavior change efforts. The following pretests examine how social cognitive theory can inform the use of VRSs as models for health behavior change.

CHAPTER NINE: PRETESTS

Five pretests[1] were conducted to explore the utility of virtual selves to model health behaviors. In Pretest 1, vicarious reinforcement was manipulated to determine if a virtual self experiencing the rewards and punishments of exercise was sufficient to encourage imitation of the exercise behavior. In Pretest 2, rewards and punishments were examined separately, and virtual selves were compared to virtual others on model effectiveness. In Pretest 3, longer-term effects of exercising virtual selves and virtual others were examined, and participants' real world exercise was measured 24 hours after exposure. In Pretest 4, physiological measures were implemented to see if there was a difference in bodily response to virtual selves and virtual others. In Pretest 5, virtual selves were incorporated in a new domain, eating, and the role of presence was examined.

Samples

All studies featured convenience samples drawn from the population of a mid-sized West Coast University. All participants were given class credit or paid $10-$15 for their participation.

Apparatus

All studies featured the same general 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 1280 horizontal by 1024 vertical pixel resolution panels. The display presented a visual field subtending approximately 50 degrees horizontally by 38 degrees vertically.

Stereoscopic images were rendered by a 1900 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. In all studies except Pretests 4 and 5, the participant's movements along the *x*, *y*, and *z* planes were tracked using WorldViz Precision Position Tracker optical tracking system. 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.

Pretest 1: Vicarious Reinforcement of Virtual Selves

Overview and Hypotheses

This study investigated the use of virtual selves 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.

Procedure

The sample (N = 63) consisted of 31 women and 32 men aged 18 to 29 (M = 20.28, SD = 1.70).[2]

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, if they wished, 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 3 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. Figure 3 shows a VRS that has lost and gained weight.

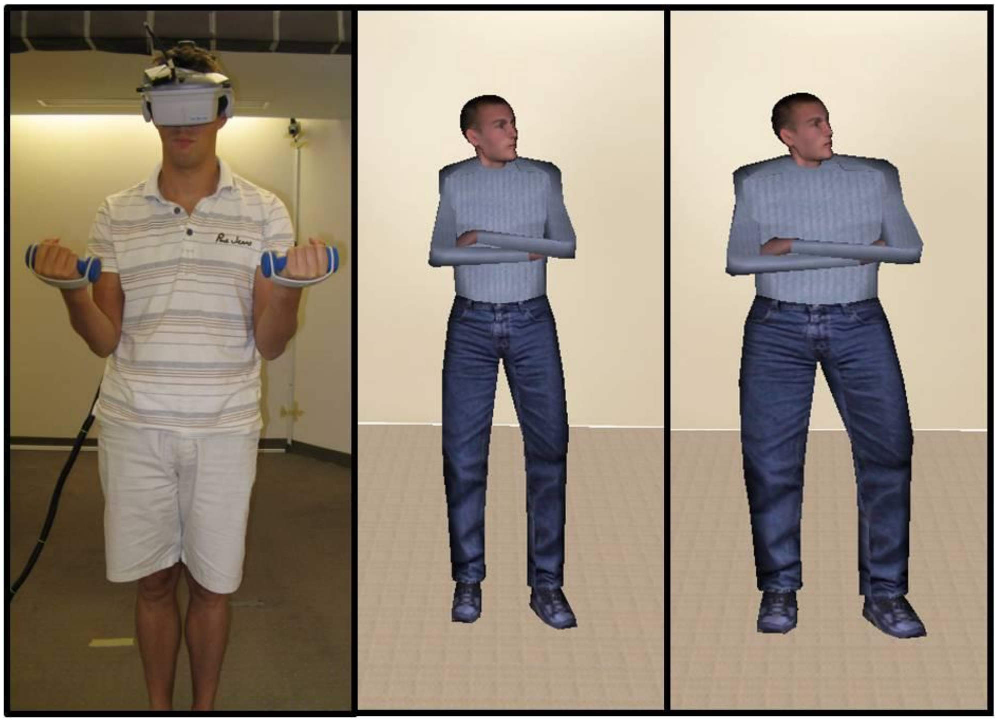

Figure 3. Example stimuli for Pretest 1. As the participant exercised (left), the avatar got slimmer (middle). If the participant did not exercise, the avatar gained weight (right).

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 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, as is seen in Figure 4.

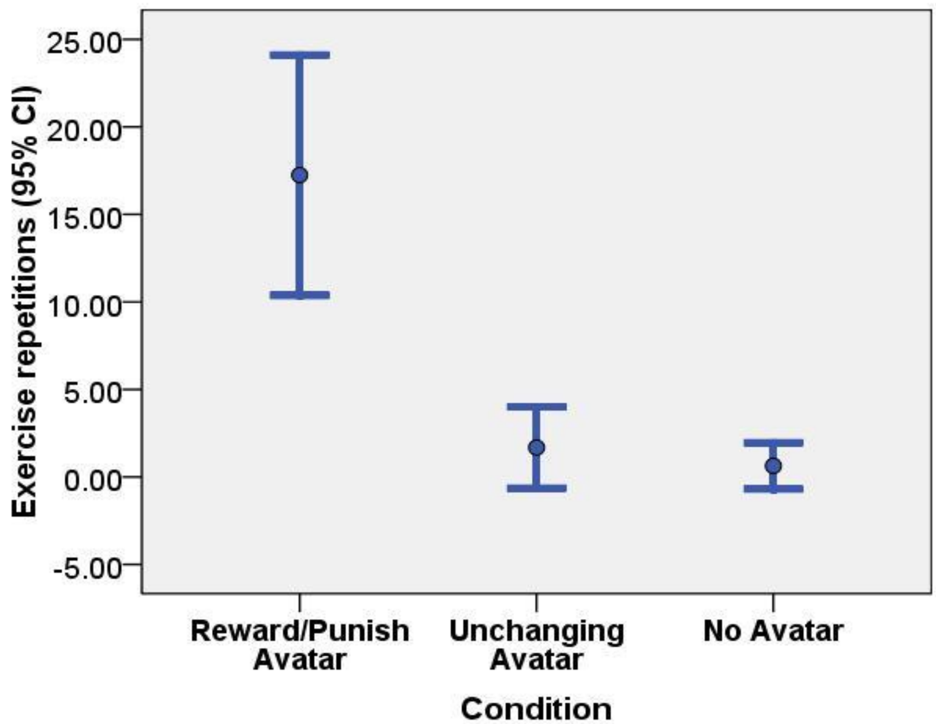

Figure 4. Results of Pretest 1. The vicariously reinforced avatar encouraged significantly more exercise than an unchanging avatar or no avatar.

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.

Pretest 2: Reward and Punishment of Virtual Selves and Virtual Others

Overview and Hypotheses

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).

Procedure

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).

A 2 x 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 five-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 ($M = 1.96$, $SD = 1.02$), $t(53) = 2.79$, $p < .01$, Cohen's $d = .75$, confirming that the self-other manipulation was successful.

Results and Discussion

A 2 x 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 $\eta^2 = .11$. The interaction effect was not significant, $F(1, 49) = .14$, $p > .05$, partial $\eta^2 = .00$. Figure 5 illustrates these findings.

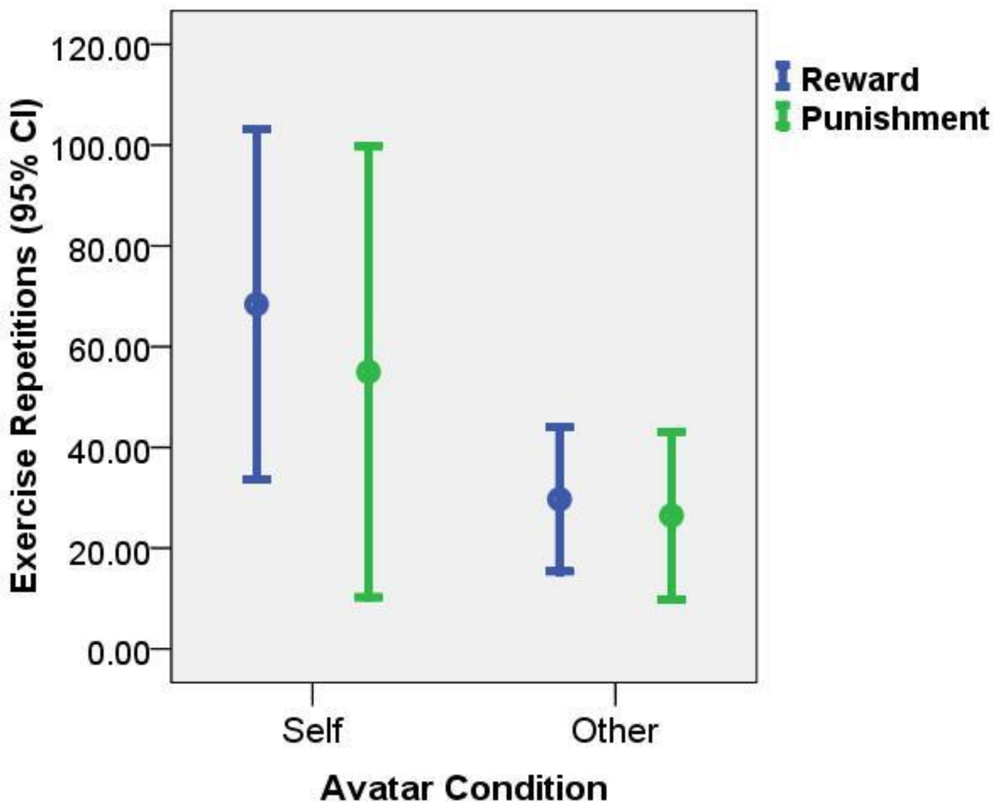

Figure 5. Results of Pretest 2. A main effect was found for seeing the virtual self experience changes as opposed to a virtual other.

This study determined that the virtual self can be used as a model 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.

Pretest 3: Effects of Exercising Virtual Selves and Virtual Others After 24 Hours

Overview and Hypothesis

Similar to Pretest 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).

Procedure

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 ($M = 20.61$, $SD = 2.50$).

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 min 20 s. During this time, they engaged in a distracter 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 distracter task, derived from previous work (Bailenson et al., 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 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 6 provides examples of running and loitering virtual humans.

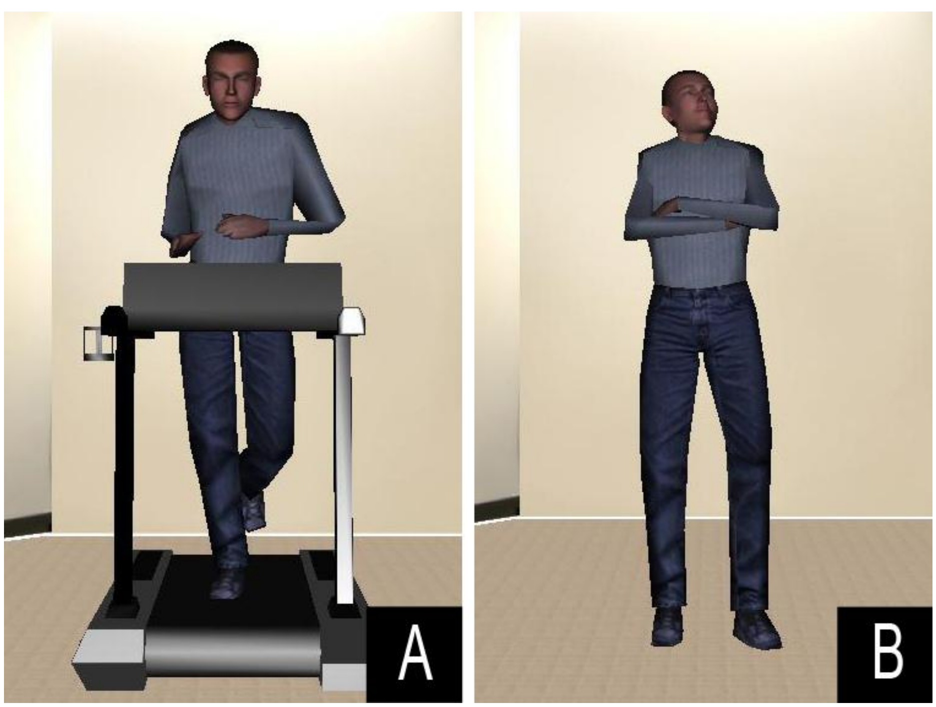

Figure 6. A running virtual human (A) and a loitering virtual human (B).

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 on paper; later, they submitted those responses electronically.

Measures

Virtual human resemblance. Participants were asked to rate on a fully-labeled five-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 *MET* (metabolic equivalent, 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).

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

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.

Table 1

Factor Loadings for Physical Activity Items

	Commute	Exercise
Commute (Cronbach's α = .41)		
City blocks walked	.785	.061
Flights of stairs climbed	.582	.175
Biking, brisk walking (Activity at 4.0 MET)	.653	-.186
Exercise (Cronbach's α = .31)		
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.

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					--

* $p < .05$

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 statistic for the factors was low (.51), it 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, as can be seen in Figure 7.

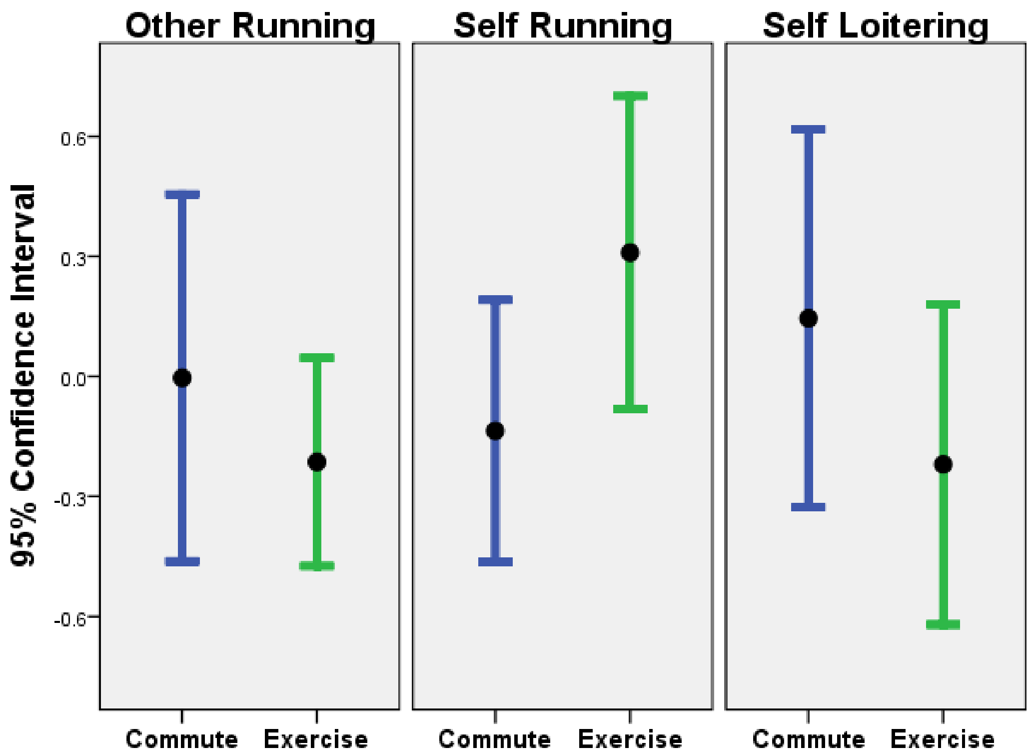

Figure 7. Results of Pretest 3. Although there were no differences in commuting, participants who saw a VRS running exercised significantly more than other conditions.

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 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.

Pretest 4: Physiological Responses to Virtual Selves and Others

Overview and Hypothesis

For this study, we wanted to address whether observing self or other models, or exercising or loitering models, resulted in differing levels of physiological arousal. Because the self-running model in the previous study led to more exercise, we hypothesized that this model may yield greater physiological arousal than a loitering self, a running other, or a loitering other (H5).

Apparatus

For this study, in addition to the virtual reality apparatus, equipment was used to gather physiological data from participants. Physiological signals were measured, amplified, and recorded using a Thought Technology ProComp Infiniti module linked to a computer. Thought Technology's Infiniti software program coordinated the sampling and storage of physiological data. Heart rate was recorded using a blood volume pulse detection sensor placed on the index finger of the non-dominant hand. Data were initially collected as interbeat intervals or milliseconds between consecutive R-spikes sampled at a rate of 256 times per second. They were then edited and converted off-line to heart rate in beats per minute. Skin conductance was recorded using standard Ag/AgCl electrodes placed on the ring finger of the non-dominant hand. The signal was sampled at a rate of 32 times per second and converted to conductance values in microSeimens (uS). See Figure 8 for a depiction of how participants were hooked up to the equipment.

Figure 8. The setup for physiological measures during immersion in the HMD.

Procedure

The sample (*N* = 22) consisted of 10 men and 12 women ranging in age from 18 to 29 (*M* = 21.64, *SD* = 3.84). Due to equipment failure and physiological nonresponse (i.e., participants were not perspiring), skin conductance data was only viable for 10 participants (five men and five women).

Participants were advised to remain as still as possible during the treatment. Each participant was presented with the four phases in a randomized order. The phases included a VRS running, a VRS loitering, a VRO running, and a VRO loitering. During each phase, participants witnessed an avatar (of either the self or another unknown person of the same sex and approximately the same age) that was either running on a treadmill or standing in place, occasionally shifting its weight or crossing its arms. Refer to Figure 6 for illustrations of a virtual representation running and loitering.

Physiological Data Processing

Heart rate. Before analyzing the heart rate data, we performed two preprocessing steps to remove noise. First, we scanned the data for outliers, which we defined as points that differed by more than three BPM from the median of their five closest neighbors. We replaced such points with the corresponding medians. Next, we smoothed the data using a "moving average," replacing each point with the mean of its five closest neighbors.

We measured heart rate elevation in terms of an increase over a baseline. As the participants' heart rates did not always return to a resting state before each phase of the experiment, we used a separate baseline for each condition. The baselines were collected by taking the average heart rate over a 5-second interval immediately preceding each phase.

Each condition lasted 160 seconds; however, we found that the participants tended to become habituated after about two minutes, causing their heart rates to return to their baseline levels. Consequently, we considered only the first 105 seconds of each phase. To calculate the percent increase in heart rate for each condition, we subtracted the baseline from the participant's average heart rate during this 105-second interval, and then divided by the baseline.

Although subtracting the baseline heart rates allowed us to take into account the differences in resting heart rates between subjects, it did not capture differences in variability. For example, a 5% increase in heart rate for a subject with low variability may be more significant than a 10% increase for a subject with high variability. To address this issue, we applied vector normalization to the four data points representing a subject's percent increase in each phase. The vector-normalized data was used for analysis.

Skin conductance. The skin conductance data was characterized by rapid spikes of varying amplitudes. Such a spike is referred to as a skin conductance response (SCR). From this data we extracted several features for each experimental phase, including the number of small, medium, and large SCRs, and the mean and maximum amplitude of all SCRs. The mean amplitudes were used for analysis.

Results and Discussion

No differences were found in heart rate across conditions, $F(3, 63) = 1.84$, $p > .05$, partial $\eta^2 = .08$. The means suggested that the VRS-Running ($M = .14$, $SD = .48$) and VRO-Loitering ($M = .15$, $SD = .50$) phases stimulated an increase in heart rate whereas the VRS-Loitering ($M = -.11$, $SD = .57$) and VRO-Running ($M = .04$, $SD = .43$) stimulated a decrease, although the differences between these phases were not significant.

Results indicated a significant difference in skin conductance across conditions, $F(3, 27) = 3.50$, $p < .05$, partial $\eta^2 = .28$. Planned contrasts in the form of paired *t*-tests revealed that participants demonstrated significantly greater skin conductance during the VRS-Running phase ($M = .29$, $SD = .49$) than during in the VRS-Loitering phase ($M = -0.30$, $SD = .41$; $t(9) = 3.27$, $p < .01$, Cohen's $d = 1.31$) and the difference from the VRO-Running phase bordered on significance ($M = -0.29$, $SD = .58$; $t(9) = 1.91$, $p = .088$, Cohen's $d = 1.08$). Interestingly, there was no difference between VRS-Running and VRO-Loitering ($M = .31$, $SD = .52$), $t(9) = .06$, $p > .05$, Cohen's $d = .04$. Additional analyses revealed that participants experienced greater skin conductance in the VRO-Loitering phase than during the VRS-Loitering [$t(9) = 2.40$, $p < .05$, Cohen's $d = 1.30$] or

VRO-Running phases [$t(9) = 2.26$, $p = .05$, Cohen's $d = 1.09$]. Results can be seen in Figure 9.

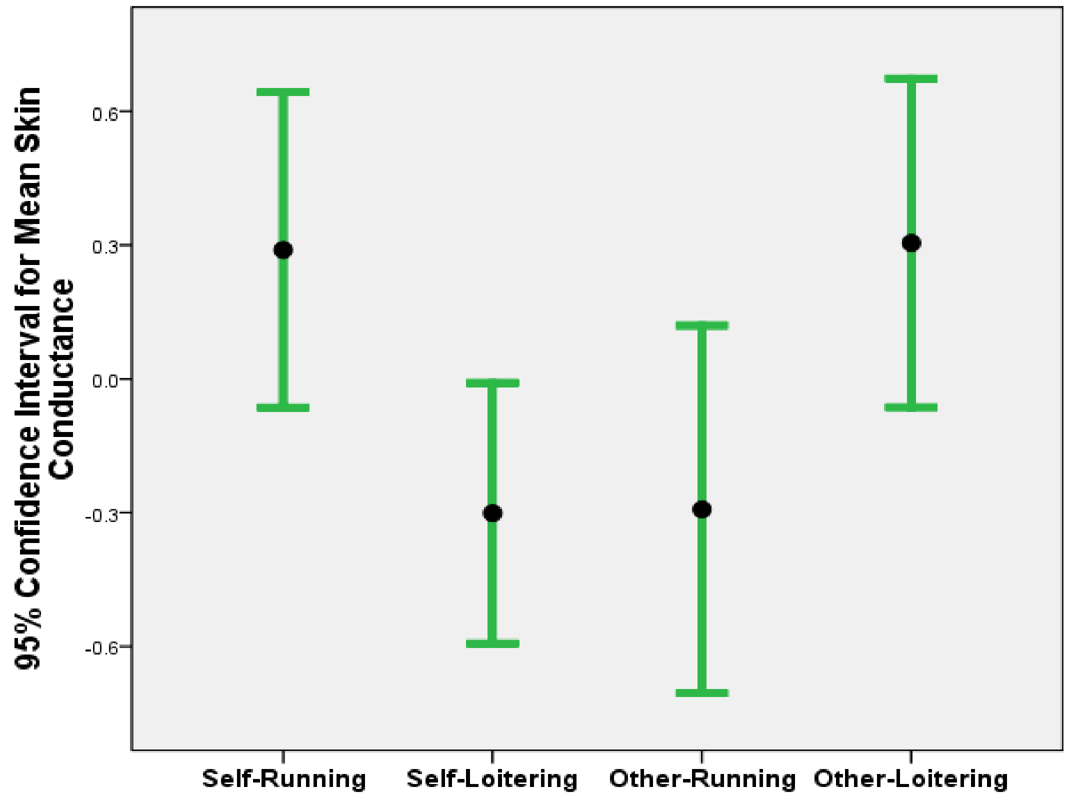

Figure 9. Results of Pretest 4. Participants experienced greater arousal to a VRS running and a VRO loitering than a VRS loitering and a VRO running.

Participants did not show a difference in heart rate across phases. This may be an artifact of the extensive data-cleaning that took place. The equipment can occasionally present erratic numbers (e.g., heart rates doubling and reverting within 1/32 of a second) and analyzing this data requires many judgments on determining the accurate readings. It is possible that our implementation of a moving average, for example, washed out some variance that would have yielded differences.

Participants experienced greater skin conductance in response to running selves and loitering others than to running others or loitering selves. It may be that running selves are stimulating in that participants feel as if they are actually engaged in the exercise. Alternatively, it may serve as a cue that summons the feelings of previous experiences with exercise, causing the body to respond in a similar physiological manner. The finding that the other loitering also caused greater physiological arousal is somewhat puzzling. However, it is possible that, in contrast to the running other (which had a clear purpose), the loitering other made participants uncomfortable and made them feel they were being watched by a stranger. The loitering self may not have resulted in discomfort and the resultant peak in arousal because it is not dissimilar to looking in the mirror, a common experience for most.

These results may offer some insight on the results of Pretest 3, wherein a running self promoted more exercise in the 24 hours following the experiment than a loitering self or a running other. Participants experienced greater physiological arousal at seeing the virtual self run than the self loitering or another person running, which may have served as a physical impetus to exercise after the experiment. Choosing to exercise after experiencing greater arousal may have been a form of excitation transfer. Future research may expose participants to these stimuli and then present them with opportunities to address this arousal in the laboratory immediately afterwards (e.g., through exercise or other physical tasks) to observe and compare differences in subsequent behavior.

Pretest 5: Presence and the Imitation of Eating Behaviors

Overview and Hypothesis

This experiment was designed 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.[3] Participants' 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 was hypothesized that those who experience high levels of psychological presence will demonstrate more imitative eating behavior than those who experience low levels of presence (H6).

Procedure

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).

A between-subjects design was employed. Participants were randomly assigned to one of two Conditions: Change (n = 32) or No Change (n = 37). 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 such:

> 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 three minutes, the eating animation would stop and the avatar would then begin to eat the other food for three minutes. 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 10 for an illustration of the changing body condition.

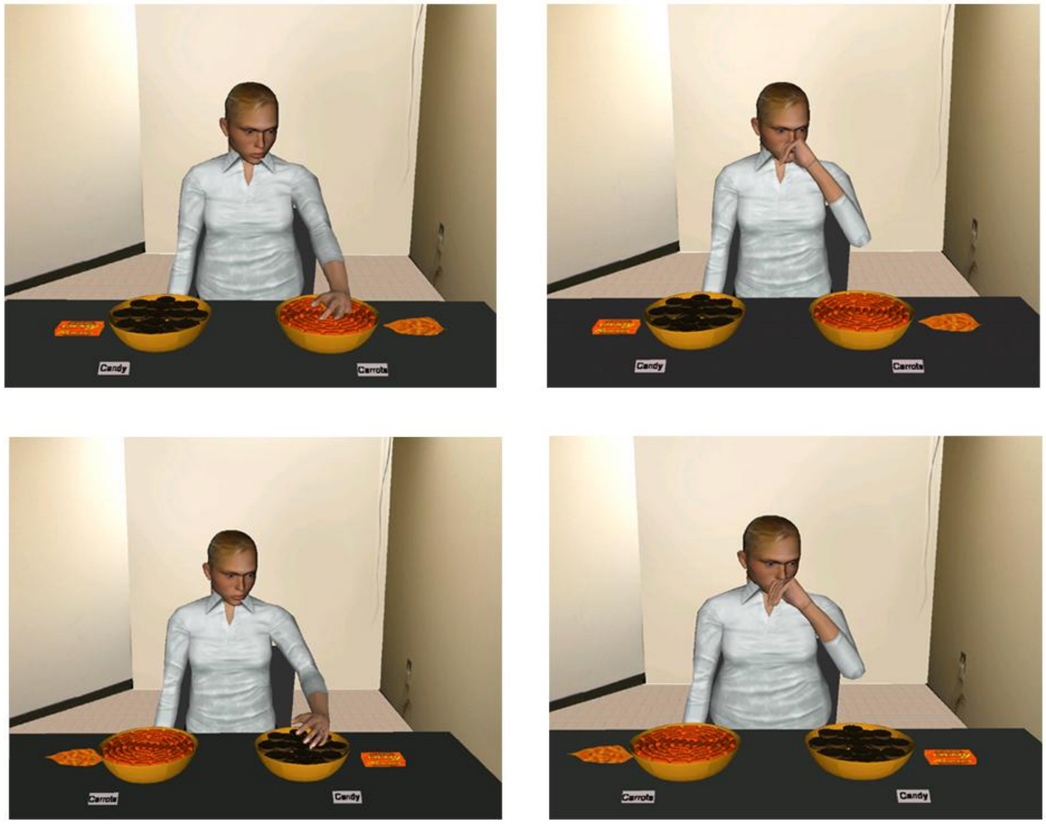

Figure 10. Example stimuli from Pretest 5. In the changing condition, participants saw a virtual self slim as it ate carrots (top row) and gain weight as it ate Reese's Cups (bottom row).

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.

Measurement

Numbers identified: presence proxy. Participants were presented with ten sets of numbers and asked which of the numbers they recalled seeing while in the virtual world. The total of numbers identified ranged from 5 to 10 (M = 8.59, SD = 1.33). The purpose of the distracter task, employed in Pretest 3 as well as previous VE studies (Bailenson et al., 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 individuals' limited cognitive resources, 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.

Self-reported presence. A subjective measure of presence was also used. Eleven 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 & Biocca, 2003; Witmer & Singer, 1998). Participants indicated on a 5-point scale (*1 = Not at all; 5 = Extremely*) the degree to which they felt present in the virtual environment. 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 = .64). A Cronbach's alpha of α = .88 was achieved.

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 0 and 8 candies (M = 1.30, SD = 2.28).

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?"

Results and Discussion

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.

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 ($M = 8.97$, $SD = .90$). 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 ($M = 2.68$, $SD = .56$) reported more presence than those in the unchanging body condition ($M = 2.38$, $SD = .68$). 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 ($M = 2.65$, $SD = .71$) to self-report more presence than women ($M = 2.41$, $SD = .55$). The interaction effect was not significant, $F(1, 65) = 1.44$, $p > .05$, partial $\eta^2 = .02$.

Hypothesis. In order to examine the role of self-reported presence on modeling the eating behavior (H6), we performed a median split to separate participants into low and high presence groups. Those scoring at or below the median (*Mdn* = 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 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 ($M = 8.94$, $SD = .95$) 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 3 candies ($n = 9$) were wisterized to 3. 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 $\eta^2 = .00$.[4] The interaction effect, however, was significant, $F(1, 53) = 4.95$, $p < .05$, 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 ($M = .36$, $SD = .94$), $t(16.41) = 2.07$, $p = .055$. High presence males ($M = 2.06$, $SD = 2.79$) ate significantly more candies than low presence males ($M = .50$, $SD = .67$), $t(17.28) = 2.16$, $p < .05$. Figure 11 depicts these findings.

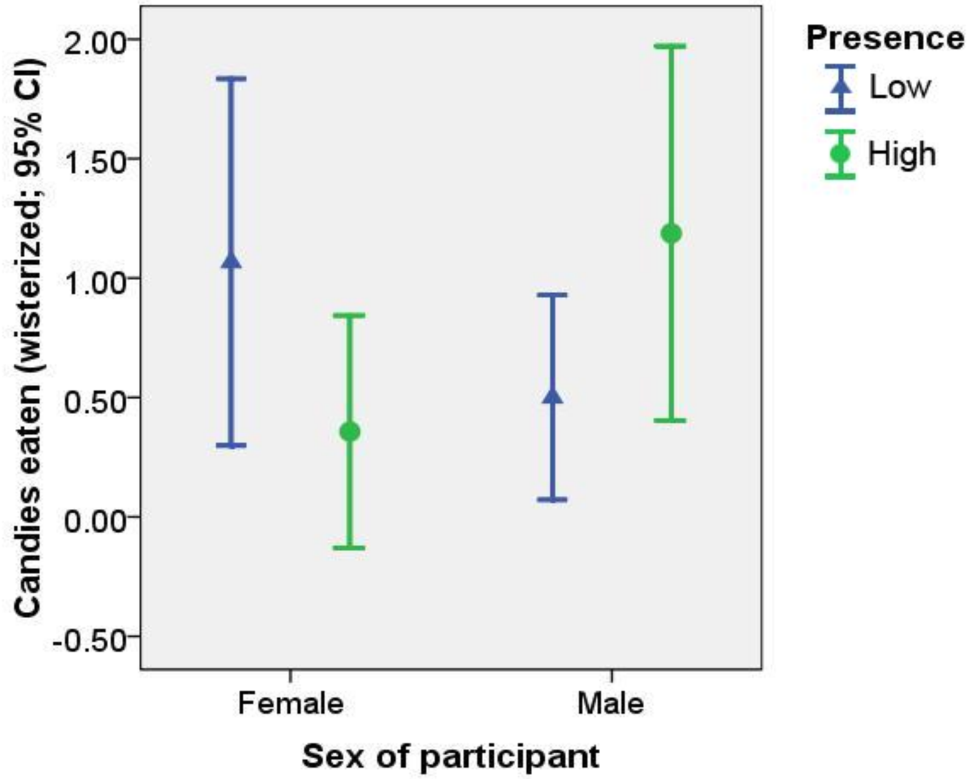

Figure 11. Results of Pretest 5. High presence men consumed more candy than low presence men, whereas high presence women consumed less candy than low presence women.

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.

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 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.

Justification for Dissertation Studies

Although these pretests have provided compelling evidence for the effectiveness of virtual treatments rooted in social cognitive theory, future research is needed to further explicate the mechanisms behind these effects and determine the utility of these technologies. The studies were designed to achieve two goals. Study 1 was designed to see if virtual models that varied on degree of similarity (self, same race as self, or different race than self) evoked different levels of identification, self-efficacy, and exercise repetitions. Study 2 was designed to consider pre-existing self-efficacy regarding exercise behavior and compare the effectiveness of virtual stimuli with another common form of exercise motivation, mental imagery.

A major shortcoming of the pretests is that the role of self-efficacy was not determined before or after the treatments were administered. 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 featured in these studies either enhanced or diminished feelings of self-efficacy, which then affected participants' exercise behaviors. Another possibility is that participants had pre-existing levels of self-efficacy regarding the modeled behavior, and those beliefs determined how (or if) the treatment was successful in promoting healthful attitudes and behavior.

The pretests compared the effectiveness of different virtual stimuli. However, it could be that the virtual environment is not necessary to have participants experience the message. Perhaps a prompt could inspire the individual to imagine the scene effectively enough to yield the same behavioral effects.

The dissertation studies were intended to answer these questions. Study 1 was designed to examine variation in the degree of identification with a model by comparing the virtual self with a similar other and a dissimilar other. This study was designed to determine whether these models would have differential effects on self-efficacy as well as exercise behavior. Study 2 considered whether a fully immersive virtual environment was necessary to yield imitation of exercising self-representations. Participants either observed their virtual selves successfully completing exercises in the VE or were asked to mentally imagine the same scene. This study also contrasted participants who had high and low pre-existing levels of self-efficacy regarding the modeled exercise behavior to see if they would be differentially affected by the two treatments.

CHAPTER TEN: DISSERTATION STUDY ONE: DEGREES OF IDENTIFICATION WITH VIRTUAL SELVES AND OTHERS

This study was designed to add further understanding to the distinction between virtual selves and virtual others. None of the pretests systematically varied the level of similarity between the self and the virtual other. Thus, this experiment was designed to compare three distinct levels of resemblance—a virtual self, a similar virtual other of the same race, and a dissimilar virtual other of a different race—to see whether different levels of identification impacted self-efficacy and exercise behaviors.

This study sought to examine, first and foremost, whether virtual self-models could be used to enhance self-efficacy regarding a specific exercise behavior, and whether these models would be more effective than similar or dissimilar models. Second, this study sought to replicate previous findings regarding the use of virtual selves to promote exercise behaviors. Because the avatars used in this study only vary in the face (and hands, which match the skin tone of the face), the extent to which resemblance could be manipulated was limited to very basic demographic variables. Given that sex has had some mixed findings (i.e., females are more likely to imitate males than males are to imitate females, see Bussey & Perry, 1982, for a discussion) and college-aged students tend to have negative conceptions towards older people (Greenberg, Schimel, & Martens, 2002; Rupp, Vodanovich, & Credé, 2005), race/ethnicity was determined to be the only viable alternative. Several studies have examined race matching and mismatching in the context of modeling and found that participants identify with race-matched models more than race mismatched models (e.g., Anderson & McMillion, 1995; Appiah, 2001; Kalichman et al., 1993; Pitts, Whalen, O'Keefe, & Murray, 1989).

The third goal of this study was to examine other variables which may explain previous findings. First, previous studies only examined resemblance as a measure of identification with the model. However, identification is a psychological process that entails more than physical likeness, and so a measure was added to determine participants' experiences of identification (Cohen, 2001). In Pretest 3, participants saw a specific form of exercise behavior, running, yet they reported an increase in various types of health behaviors beyond running. It could be that these stimuli cue a general exercise efficacy schema, not just to the specific behavior, which is why exercise in general increased. Thus, general exercise self-efficacy was also considered. Finally, in Pretest 5, presence was shown to play a role in the subsequent imitation of behavior, so this measure was also included. The following hypotheses and research questions were proposed:

H1: Participants in the Self condition will report higher levels of identification with their avatar than those in the Similar Race condition, who will report higher levels of identification than those in the Dissimilar Race condition.

H2: Participants in the Self condition will report higher levels of specific exercise self-efficacy than those in the Similar Race condition, who will report higher levels of specific self-efficacy than those in the Dissimilar Race condition.

H3: Participants in the Self condition will complete more exercise repetitions than those in the Similar Race condition, who will complete more exercise repetitions than those in the Dissimilar Race condition.

RQ1: Will there be a difference in general exercise self-efficacy across conditions?

RQ2: Will there be a difference in presence across conditions?

Method

Sample

A convenience sample was obtained from the student population of a medium-sized West Coast university. The initial sample consisted of 80 participants, but four were dropped due to technological difficulties and one was dropped due to failure to follow instructions. The final sample (N = 75) consisted of 38 women and 37 men aged 18 to 44 (M = 20.95, SD = 3.50). Participants self-reported their race/ethnicity as Caucasian/European-American/White (44%; n = 33); African/African-American/Black (12%; n = 9); Latino/a (8%; n = 6); Asian/Asian-American (22.7%; n = 17); American Indian (1.3%; n = 1); and Other or multiple races/ethnicities (10.7%; n = 8).

Design

A between-subjects design was employed. Participants were randomly assigned to one of three conditions, *Self* (n = 26), *Similar Race Other* (n = 24), or *Dissimilar Race Other* (n = 25).

Procedure

The experimental procedure was the same as employed in Pretests 1 and 2. Participants in all three conditions were provided with a prompt describing the phases of the experiment and the exercise they would be performing. A research assistant demonstrated the exercise once to illustrate proper technique and explain how the repetitions would be counted. Then, the participant was fitted in the HMD and immersed in the virtual environment.

The experiment was structured in three phases that were consistent across conditions. Participants performed behaviors in physical space while viewing the virtual room in the HMD. In the first phase, participants performed three sets of 20 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.

The phases were the same across conditions, and the stimulus was the same aside from the manipulation. In every condition, participants viewed a virtual human from the third person, consistent with the Pretests. That is, the participant did not embody the virtual human; rather, it was standing in the room facing the participant. The virtual human started at an average body weight, but participants saw the virtual humans 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 virtual human slimmed slightly. In the second phase of mandatory inactivity, every three seconds the slimmed-down virtual human regained some weight until it appeared overweight. For the third phase, the virtual human was reset to the initial weight, and then it appeared to lose or gain weight in accordance with the participant's exercise or inactivity.

The avatars used in this study were designed using the same procedure as in all the Pretests. Participants had their photographs taken with a digital camera and their virtual head models were constructed. For the *Self* conditions, these heads were affixed to a sex-appropriate generic avatar body. For those assigned to the *Similar Race* or *Different*

Race conditions, a head of an unknown, same-sex other person was randomly selected from a pool of previous participants. For those in the *Similar Race* condition, a head of the same race as the participant had indicated on their demographic information was selected. For those in the *Dissimilar Race* condition, a head of a different race was selected. For multiracial participants, the head chosen was not of any of the races/ethnicities that the participant indicated as their own. One update was made in the avatar building since the Pretests: new, more realistic bodies from the Complete Characters avatar library were used. Examples of these avatars can be viewed in Figure 12.

Figure 12. Example stimuli for Study 1. Top: a Black female avatar at (from left) normal, slim, and heavy weight. Bottom: a White male avatar at normal, slim, and heavy weight.

Measures

Items for all measures included in this study can be viewed in Appendix A.

Avatar resemblance. Three items were used to assess the self-other manipulation. Participants were asked to indicate on a 5-point scale (1 = *Not at all*; 5 = *Extremely*) the degree to which they believed the avatar resembled them in the face, the body, and overall (M = 2.34, SD = .76). Reliability for this measure was Cronbach's α = .74.

Avatar race. For manipulation check purposes, participants were asked to identify the avatar's race/ethnicity as White, Black, Latino/a, Asian, or Other.

Racism. To ascertain that the stimulus did not create negative racial associations, six items from the Modern Racism Scale (McConahay, 1982; McConahay, Hardee, & Batts, 1981) were adopted. Items were reworded slightly for modernization purposes (e.g., "Over the past few years minorities have gotten more economically than they deserve.") The items were embedded with 14 filler items in a purportedly unrelated test of political attitudes. One item was dropped, leaving the scale consisting of five items (M = 2.00, SD = .87). Reliability for this measure was Cronbach's α = .88.

Identification. Eight items were adapted from Cohen (2001) and used to assess participants' feelings of identification with the avatar. Because the items were originally written to assess identification with television characters, some were reworded to fit the stimulus and the term "my representation" was used instead of "the character." Participants indicated on a 5-point scale (1 = *Strongly disagree*; 5 = *Strongly agree*) their agreement with statements including "At key moments, I felt I knew exactly what my representation was going through" and "I think I have a good understanding of my representation." Responses were averaged; scores ranged from 1.33 to 4.44 (M = 2.84, SD = .75). A Cronbach's alpha of α = .80 was achieved.

Presence. The same subjective measure of presence from Pretest 5 was also used. Eleven items were used to assess participants' experience of presence while immersed in the virtual world. Participants indicated on a 5-point scale (*1 = Not at all; 5 = Extremely*) the degree to which they felt present. Responses were averaged; scores ranged from 1.75 to 4.17 (*M* = 2.89, *SD* = .66). A Cronbach's alpha of α = .90 was achieved.

Specific exercise self-efficacy. Seven items were developed to assess participants' self-efficacy towards the specific exercise demonstrated by the virtual model, marching in place. Bandura's (1997) guidelines regarding the level, generality, and strength of efficacy beliefs were incorporated in the development of the measure. To parallel exercise performance in the real world, the items were then framed given the Surgeon General's recommendations on exercise (30 minutes a day). Participants indicated on a five-point scale (1 = *Strongly disagree*; 5 = *Strongly agree*) their agreement with statements including "I could perform the exercise I saw in the real world at a steady rate for 30 minutes" and "I would be successful performing the exercise I saw at a steady rate for 30 minutes." Responses were averaged; scores ranged from 1.00 to 5.00 (*M* = 3.78, *SD* = .99). A Cronbach's alpha of α = .92 was achieved.

General exercise self-efficacy. Bandura (1997) noted that an error in self-efficacy measurement is that it is often aimed too broadly (e.g., at general health behavior rather than the specific behavior modeled). Since Pretest 3 had indicated that there was an effect on general exercise behavior after a similar stimulus, however, a measure of general exercise self-efficacy was added to see if feelings towards exercise in general were enhanced by the treatment (Sallis, Pinski, Grossman, Patterson, & Nader, 1988). Fifteen items addressed participants' confidence whether they could "Stick to an exercise program after a long, tiring day at school or work" and "Make time, even on the weekends, to exercise" (1 = *Very confident I could not do it*; 5 = *Very confident I could do it*). Responses were averaged; scores ranged from 1.20 to 5.00 (M = 3.60, SD = .91). A Cronbach's alpha of α = .95 was achieved.

Exercise repetitions. As in Pretests 1 and 2, the behavioral 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. Fifty-seven participants (76%) chose to exercise during the third phase; the number of repetitions performed ranged from 0 to 189 (M = 40.39, SD = 40.80).

Results

Manipulation Checks

Participants were asked to note the degree to which they felt the avatar resembled them to determine whether the self-other manipulation was successful. There was a significant difference across conditions, $F(2, 72) = 19.37$, $p < .0005$, partial $\eta^2 = .35$. Follow-up tests with Bonferroni corrections indicated that participants in the Self condition (M = 2.76, SD = .66) rated the avatars as resembling them more than those in the Dissimilar condition (M = 1.72, SD = .58), $t(49) = 5.95$, $p < .0005$, Cohen's d = 1.67, and those in the Similar condition (M = 2.53, SD = .62) perceived more resemblance than those in the Dissimilar condition, $t(47) = 4.73$, $p < .0005$, Cohen's d = 1.35. However, there was no significant difference between the Self and Similar conditions, $t(48) = 1.26$, $p > .05$, Cohen's d = .36. Thus, the Self manipulation failed.

Participants were also asked to indicate the avatar's race. Fifty-one participants (68%) correctly identified the avatar's race and 24 (32%) did not. Of those that did not, 6

(8%) were in the Dissimilar condition and although they did not identify the avatar's race correctly, did identify the race as one dissimilar to their own. Thus, a total of 57 participants (74%) correctly recognized that the avatar's race was similar or dissimilar to their own and the manipulation failed for 18 participants (26%). Surprisingly, this failure to distinguish the avatar's race was not isolated to the Other conditions, as 26.9% of participants in the Self condition (7 of 26) failed to correctly identify the avatar's race. Indeed, a chi-square analysis revealed there was no significant differences across conditions on correct identification of the avatar's race, χ^2 [N = 75] = .64, $p > .05$.

Finally, participants' attitudes about race were assessed. There were no significant differences across conditions, $F(2, 65) = .79$, $p > .05$, partial $\eta^2 = .02$. Participants in the Self (M = 1.90, SD = .93), Similar (M = 1.91, SD = .82), and Dissimilar (M = 2.19, SD = .84) conditions did not differ on the Modern Racism Scale.

Hypotheses and Research Questions

Means and standard deviations for all dependent variables can be viewed in Table 3.

Table 3

Study 1 Means and Standard Deviations for Dependent Variables by Condition and Sex

DV	Resemblance		Identification		Specific SE		Exercise Repetitions		Presence		General SE	
Condition	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Self	2.76	.66	2.88	.83	3.76	1.08	41.54	40.67	2.87	.72	3.81	.96
Men	2.95	.62	2.93	.82	3.48	1.22	51.46	53.81	2.99	.75	4.04	.71
Women	2.56	.67	2.84	.86	4.04	.89	31.62	19.70	2.76	.69	3.59	1.15
Similar	2.53	.62	2.71	.68	3.96	.90	47.58	43.53	2.90	.63	3.51	1.04
Men	2.58	.59	2.48	.72	4.25	.87	45.41	47.82	2.88	.71	3.91	.90
Women	2.47	.67	2.94	.58	3.68	.87	49.75	40.80	2.92	.55	3.11	1.05
Dissimilar	1.72	.58	2.92	.74	3.63	.98	32.28	38.03	2.91	.67	3.46	.70
Men	1.61	.57	3.15	.80	3.89	.97	41.41	40.93	3.21	.63	3.73	.46
Women	1.82	.59	2.70	.65	3.39	.96	23.85	34.60	2.63	.59	3.22	.80
Overall	2.34	.76	2.84	.75	3.78	.99	40.39	40.80	2.89	.66	3.60	.91

Identification. To test H1, a one-way ANOVA was performed on identification. No significant difference in identification was found between conditions, $F(2, 72) = .51$, $p > .05$, partial $\eta^2 = .01$. H1 was not supported.

Specific self-efficacy. For H2, a one-way ANOVA was performed on specific exercise self-efficacy. No significant difference in specific self-efficacy was found between conditions, $F(2, 72) = .70$, $p > .05$, partial $\eta^2 = .02$. H2 was not supported.

Exercise repetitions. For H3, a one-way ANOVA was performed on exercise repetitions. No significant difference in exercise repetitions was found between conditions, $F(2, 72) = .51$, $p > .05$, partial $\eta^2 = .01$. H3 was not supported.

General self-efficacy. For RQ1, a one-way ANOVA was performed on general exercise self-efficacy. No significant difference in general self-efficacy was found between conditions, $F(2, 72) = 1.10$, $p > .05$, partial $\eta^2 = .03$.

Presence. For RQ2, a one-way ANOVA was performed on presence. No significant difference in presence was found between conditions, $F(2, 72) = .02$, $p > .05$, partial $\eta^2 = .00$.[5]

Additional Analyses

Because the manipulations themselves failed, further analyses were run. First, sex was considered as a factor. Then, the conditions were variously combined to examine whether previous work was conceptually supported. Finally, the stimuli were re-examined and recoded on variables that may have influenced the findings.

Although sex had not been a significant factor in any of the Pretests involving exercise, sex was entered as a factor and 3 by 2 factorial ANOVAs were run on the variables of interest (identification, specific exercise self-efficacy, exercise repetitions, presence, and general self-efficacy). Results of these analyses can be viewed in Appendix B. The only significant effect was a main effect on general self-efficacy, indicating that men reported higher general exercise self-efficacy than women, $F(1, 69) = 8.29$, $p < .01$, partial $\eta^2 = .11$. One other effect bordered on significance, an interaction between condition and sex on specific self efficacy, $F(2, 68) = 2.68$, $p = .076$, partial $\eta^2 = .07$. There was a trend wherein men reported more specific self-efficacy in the Similar Race condition than the Dissimilar Race condition and the Self condition. The trend for women followed the hypothetical relationship; they reported more specific self-efficacy in the

Self condition than the Similar Race and Dissimilar Race conditions, as can be seen in Figure 13.

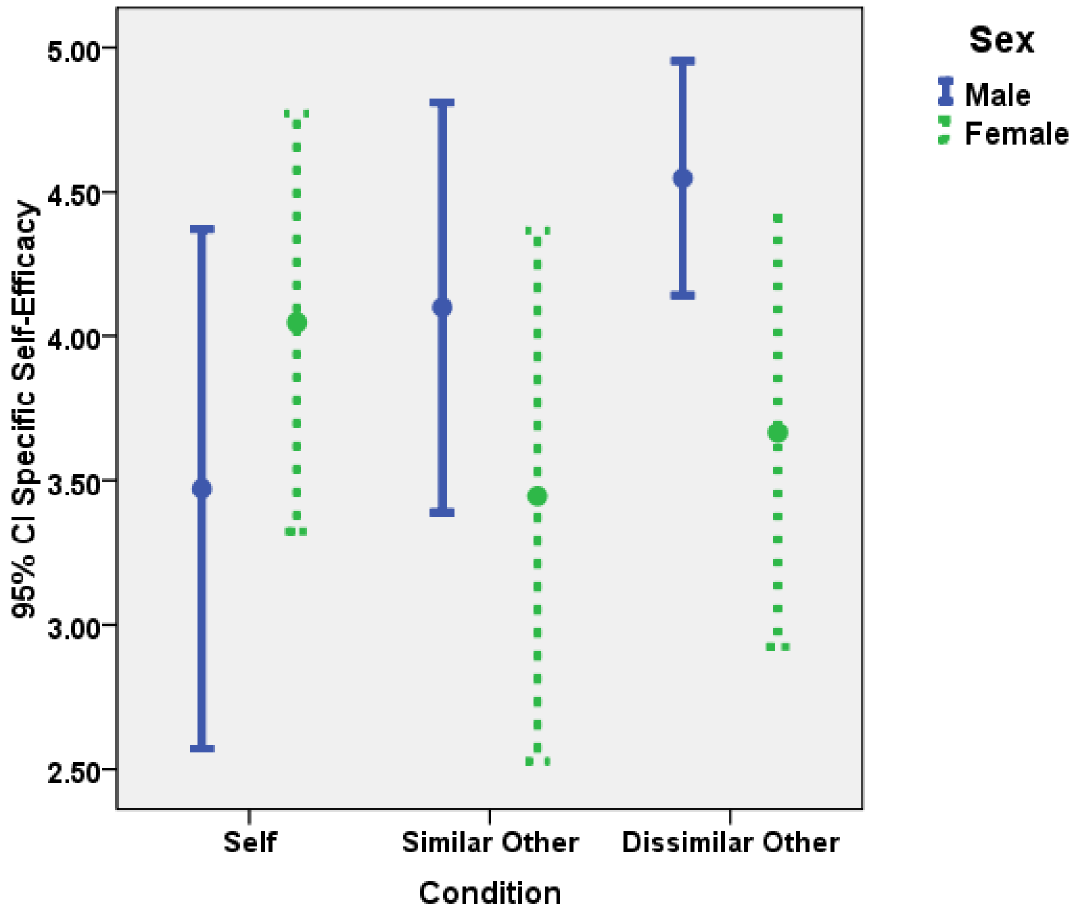

Figure 13. Specific self-efficacy by Condition and Sex. The interaction effect reached borderline significance (p = .076).

Combining the assigned conditions in analyses also did not support hypothetical relationships. In light of previous studies, we would expect that the Self would elicit more exercise than the Other categories, but this was not supported by the data; there were no significant differences between the means of the Self (M = 41.54, SD = 40.97) and combined Similar Race Other and Dissimilar Race Other (M = 39.83, SD = 41.55) conditions, $t(72)$ = .17, p > .05. There were also no differences in identification, presence, specific exercise self-efficacy, or general exercise self-efficacy using these distinctions; means, standard deviations, and results of these analyses can be viewed in Appendix C. Alternatively, the Self and Similar Race Other categories, given they were determined not to be considered different in resemblance, could be combined and contrasted to the Dissimilar Race condition. However, independent samples *t*-tests revealed no differences between these two categories either. Means, standard deviations, and results of these tests can be viewed in Appendix D. Clearly, the conditions designated by the experimenter failed in some fundamental way.

Given these unexpected findings, as well as participants' spontaneous responses and the experimenters' observations, further analyses on the stimuli themselves were also pursued. Two independent coders (one male, one female) were recruited to code all of the heads used as stimuli on attractiveness and naturalness (i.e., whether the head looked natural or computer-generated). For the Self heads, the coders also measured the attractiveness of the photos the heads were based on (to determine if there was a discrepancy between the participant's attractiveness and their head's attractiveness) as well as the degree to which the head accurately represented the photograph. Following Hayes and Krippendorff (2007), Krippendorff's alpha for interval-level measurements was used to calculate reliability, which was deemed acceptable at $\alpha = .74$. Coders' ratings were then averaged within the coding categories.

The coding revealed that there was a significant difference in between the participants' attractiveness in photos ($M = 3.17$, $SD = .55$) and the attractiveness of their heads ($M = 2.44$, $SD = .68$), $t(25) = 4.38$, $p < .0005$. There were also significant differences in head attractiveness across conditions, $F(2, 72) = 14.49$, $p < .0005$, partial $\eta^2 = .29$. A follow-up LSD test revealed that heads from the Similar ($M = 3.29$, $SD = .75$)

and Dissimilar (*M* = 3.44, *SD* = .71) conditions were ranked as more attractive than those in the Self condition (*M* = 2.44, *SD* = .68). The heads also differed significantly on naturalness, $F(2, 72) = 3.94$, $p < .05$, partial $\eta^2 = .10$. A follow-up LSD test revealed that heads from the Similar (*M* = 3.79, *SD* = 1.03) and Dissimilar (*M* = 3.70, *SD* = .74) conditions were more natural-looking than those in the Self condition (*M* = 3.13, *SD* = .92).

Because attractiveness has been shown to be an important factor in model imitation (i.e., observers are less likely to imitate unattractive models), participants whose models had heads that were rated below 3 (the midpoint of the scale) were eliminated, and the remainder were analyzed. This process also eliminated heads that were ranked as below average on naturalness. Previous tests had shown the discrepancy in attractiveness across conditions, and when the unattractive heads were removed, the Self condition (*n* = 10) was disproportionately impacted compared to the Similar (*n* = 21) and Dissimilar (*n* = 21) conditions. Also, limiting the sample size adversely impacted the power to detect differences (Cohen, 1988). Thus, the following analyses should be considered cautiously.

A one-way ANOVA was run to see if the predicted effect on exercise modeling occurred; the test showed a borderline significant difference, $F(2, 49) = 5.48$, $p = .075$, partial $\eta^2 = .29$. The means were in the predicted direction. Followup LSD tests revealed that although there were no differences between Self (*M* = 64.80, *SD* = 53.09) and Similar Other (*M* = 48.05, *SD* = 39.85), Self was significantly different than Dissimilar Other (*M* = 29.48, *SD* = 34.86); see Figure 14. No difference was found between participants in the Similar and Dissimilar conditions.

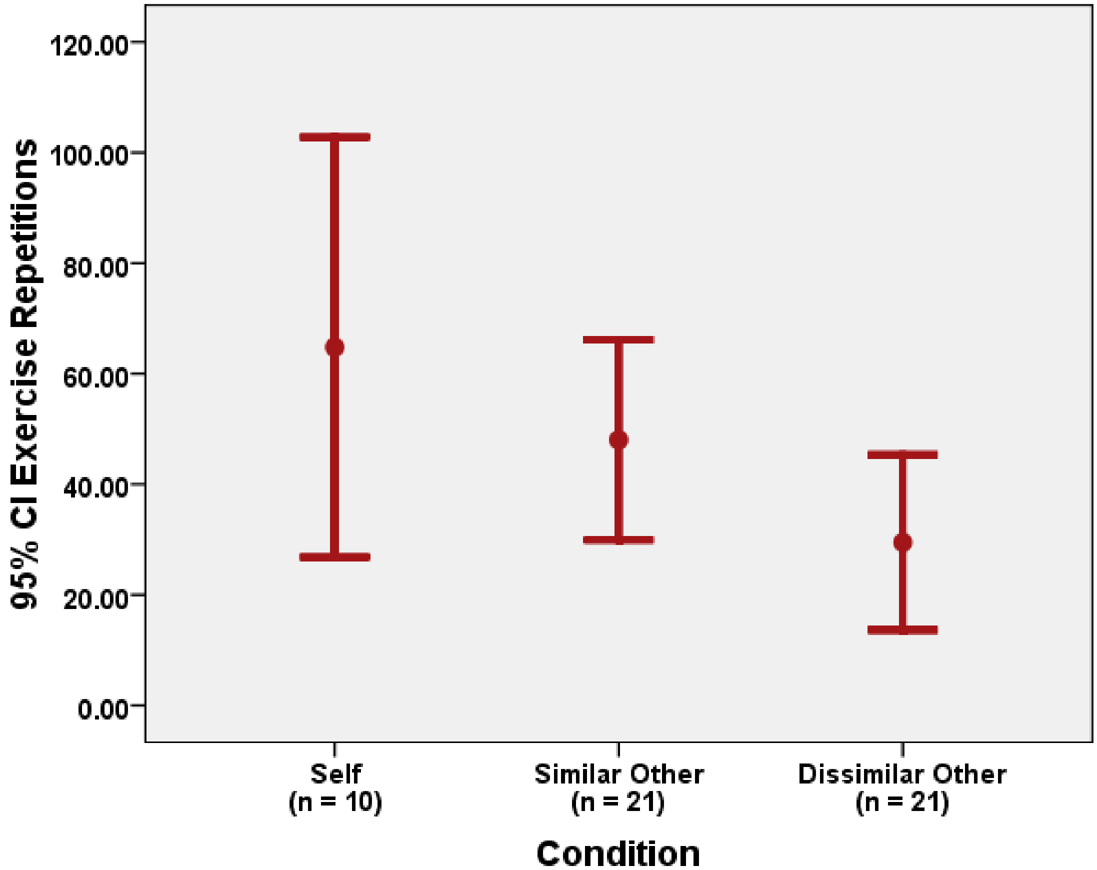

Figure 14. Effect of Condition on exercise repetitions after removal of unattractive stimuli. The effect was borderline significant ($p = .075$).

Regarding specific self-efficacy, although the means were also in the predicted direction, a one-way ANOVA revealed no differences between Self ($M = 4.21$, $SD = .77$), Similar Other ($M = 3.95$, $SD = .92$), and Dissimilar Other ($M = 3.58$, $SD = 1.02$), $F(2, 49) = 1.76$, $p = .18$, partial $\eta^2 = .07$. Thus, eliminating problematic subjects yielded means that generally followed the trends anticipated by the hypotheses for exercise repetitions and specific self-efficacy. No significant differences were found for identification [$F(2, 49) = 1.33$, $p > .05$, partial $\eta^2 = .05$], presence [$F(2, 49) = .43$, $p > .05$, partial $\eta^2 = .02$], or general self-efficacy [$F(2, 49) = .67$, $p > .05$, partial $\eta^2 = .03$].

Additionally, further analyses were conducted to examine participants' responses independent of the assigned conditions. Pearson correlations were run to see if other relationships existed among the dependent variables. These tests indicated that resemblance, identification, presence, and exercise repetitions were all significantly and positively correlated, although none of these were related to specific or general self-efficacy. These correlations can be examined in Table 4.

Table 4

Pearson Correlations between Study 1 Dependent Variables (N = 75)

DV	Resemblance	Identification	Presence	Spec. SE	Gen. SE	Exercises
Resemblance	--	.31**	.29*	.12	.02	.37**
Identification	.31**	--	.77**	-.03	-.06	.45**
Presence	.29*	.77**	---	-.01	-.22	.36**
Specific SE	.12	-.03	-.01	--	.16	.09
General SE	.02	-.06	-.22	.16	--	-.13
Exercises	.37**	.45**	.36**	.09	-.13	--

**Correlation is significant at p < .01. *Correlation is significant at p < .05.

The assertions of this line of research are that the more a person feels an avatar resembles the self and the more he or she identifies with the avatar, the more inclined the individual will be to imitate an avatar’s actions. Based on these assertions and the observed correlations, a model was hypothesized. A regression was run using exercise repetitions as the dependent variable and resemblance, identification, and presence as predictor variables. Regression analysis indicated that the set of predictors performed better than chance at predicting exercise repetitions, $R = .51$, Adjusted $R^2 = .23$, $F(3, 72) = 8.28$, $p < .0005$. Two of three predictors significantly predicted exercise repetitions. Higher levels of perceived resemblance were associated with more exercise repetitions, $\beta = .25$, $t = 2.35$, $p < .05$. Higher levels of identification were also associated with more exercise repetitions, $\beta = .36$, $t = 2.22$, $p < .05$. Presence was not a significant predictor, $\beta = .02$, $t = .10$, $p > .05$.

Discussion

The major issue with this study is that the intended manipulations failed. Participants did not perceive the Self avatars as resembling them more than the Similar avatars. Thus, it is unsurprising that we did not see a replication of previous results wherein Self avatars yielded more exercise behaviors; in previous studies the participants always perceived the Self avatars as resembling the self more than Other avatars, which is believed to be the mechanism that motivates participants to model the behavior. It should also be noted that the race manipulation was also unsuccessful for one quarter of participants. Due to the failure of the conditions in creating clearly delineated categories based on degrees of self-resemblance as defined by race, the data were re-examined based on the fundamental variables believed to influence outcomes.

Another issue with the conditions is that there were unintended qualitative differences. The Self avatars were determined to be less attractive and less natural than the avatars in the Similar and Dissimilar conditions. Additionally, some of the Self avatars were determined to be inaccurate representations of the participants. These discrepancies undoubtedly influenced the findings. People react more positively to attractive people and are more persuaded by them as opposed to unattractive people (Dion, Berscheid, & Walster, 1972; Langlois, Kalakanis, Rubenstein, Larson, Hallam, & Smoot, 2007; Reihnard, Messner, & Sporer, 2006). Observers are also more likely to imitate attractive models than unattractive ones (Bandura, 1977; Van Leeuwen, Veling, Van Baaren, & Dijksterhuis, 2009). Yee and Bailenson (2007) also found that people who embodied unattractive avatars disclosed less and maintained more personal distance to a confederate than those in attractive avatars. Thus, viewing an unattractive head, particularly one that is discrepant from one's own attractiveness, may have influenced the findings, particularly in the Self condition because more than half of the heads were determined to be unattractive or unnatural.

Removing the problematic heads from the sample and reanalyzing the remaining participants revealed a trend toward supporting previous findings that the virtual self is more effective than other representations in encouraging modeling behavior. The means also gave a general indication that the degree of similarity was related to the number of exercises performed, with Self avatars yielding the most exercise, followed by Similar avatars, and Dissimilar avatars promoted the least. Future studies should consider the role of attractiveness as well as similarity when selecting models.

In line with previous findings and conceptual predictions, the more participants felt the avatar resembled them and the more they identified with the avatar, the more exercises they performed. These findings, in addition to the Pretests, support the arguments of social cognitive theory and the proposed role of identification in behavioral modeling. Although the manipulated conditions were not effective in creating the variation in resemblance and identification that they intended to, the findings still support the conceptual assertions of this research: when people observe an avatar, the more they believe it resembles them, the more they identify with it, and the more likely they are to imitate the avatar's modeled behavior. Thus, more careful construction of these virtual representations of the self to maximize resemblance should continue to prove effective at motivating people to exercise.

It is interesting to note that only some borderline effects were found on exercise-specific self-efficacy despite the differences in identification and, in some analyses, exercise performance. One possibility is that the measure was flawed. Although the measure was adapted from suggestions made by Bandura (1997) and it proved to be reliable, it has not been validated elsewhere. The measure did not perfectly parallel the stimulus; the items considered a 30 minute time frame to reflect effective real world exercise conditions, whereas the stimulus did not last 30 minutes. Future studies should ensure a direct parallel to the stimulus (indeed, a correction that informed the scale development in Study 2). Another possibility supported by the model above is that the identification evoked by a self-resembling avatar independently influences modeling without impacting the individual's cognitions regarding his or her ability to perform the exercise. Future studies should continue to measure exercise-specific self-efficacy to see if it can be influenced by virtual self models, and the construct should also be examined alongside identification to determine their independent contributions to the variance in modeling behavior.

One explanation for the failure of the Self manipulation is that most of the heads made for this condition were made specifically for this study, whereas the Other heads were drawn from previous participants. In the past, considerably more time and technical personnel were allotted towards the crafting of the heads, allowing for more time to use Photoshop to clean up poor photographs (e.g., those with uneven lighting) and more time to test and rebuild heads that were not optimal. Unfortunately, limited resources and deadlines did not allow for as much processing with new photographs and participants, and this inadvertently created a difference in the quality between the Other heads and the Self heads. People may have reacted negatively to an inaccurate and less attractive version of themselves. The experience may have been aversive enough to make participants not want to interact with this version of the self, hence limiting their desire to exercise and remain in the environment wherein they would continue to see the misrepresentation face-to-face. In the future, head quality should be maximized and pretested to ensure qualitative differences do not exist between conditions.

Study 1 attempted to manipulate stimuli in order to impact participants' exercise behaviors and specific self-efficacy. It did not consider the role that pre-existing self-efficacy may play in how observers respond to virtual selves. Study 2 was designed to consider its role and also to compare virtual environments with a new form of treatment, mental imagery.

CHAPTER ELEVEN: DISSERTATION STUDY TWO: COMPARING VIRTUAL AND IMAGINED STIMULI FOR HIGH AND LOW SELF-EFFICACY PARTICIPANTS

Another lingering question from this line of research is a practical one: is an immersive virtual environment necessary to evoke the exercise behavior response? Immersive virtual environments are costly and not widely available; creating the virtual stimulus, particularly building the virtual self, is time-consuming; and the equipment can be considered cumbersome. If the same effects can be yielded using mental imagery, a cost-free and unencumbered method with minimal time invested in stimulus creation, then many of the supporting arguments for the advantages of treatments implementing immersive virtual environments become null. Thus, Study 2 was designed to compare the effects of virtual reality and mental imagery stimuli on low and high self-efficacy participants.

Mental Imagery

Mental imagery (MI) is defined as a cognitive activity in which one perceives a stimulus without the stimulus being present, possibly leading to a subjective experience as if the stimulus actually were present (Kosslyn, 1981; Kosslyn, Thompson, & Ganis, 2006). Mental practice (MP), more specifically, is the "symbolic, covert, mental rehearsal of a task in the absence of actual, overt, physical rehearsal" (Driskell, Copper, & Moran, 1994, p. 481). Mental imagery has been shown to be a powerful motivational tool that can alter subsequent attitudes and behaviors. Typically, mental imagery is invoked using a written prompt or oral instructions that give the audience specific instructions on what they should be sensing in their "mind's eye." Participants close their eyes and use their cognitive resources to recreate a scene that may focus on the details of the performance of a particular behavior, the environment in which it takes place, or the outcomes that it may yield. The use of mental practice has been shown to promote task self-efficacy as well as enhanced skill performance (Cumming, 2008; Driskell et al., 1994; Feltz, 1984; Martin & Hall, 1995). Visualization techniques are commonly used to promote healthy behaviors as well as to develop athletic skills (Hausenblas, Hall, Rodgers, & Munroe, 1999). Mental practice of exercise can even lead to the same physiological responses as actual exercise (Wang & Morgan, 1992).

Like virtual environments, mental imagery provides the opportunity to create stimuli that may not be possible in the physical world. Mental imagery also allows for the individual to create a rich, multi-channel stimulus similar to what can be created using virtual technologies. However, virtual environments do have some advantages to visualization techniques. Some people may have trouble imagining a particular scene because they do not have sufficient knowledge; for example, a runner might not know how her legs should be positioned to effectively clear a hurdle. A virtual environment may be seen as more entertaining or interesting than a visualization task (Vorderer, 2000), so participants may be more motivated or engaged in a virtual environment. Additionally, there is the question of required mental effort.

Cognitive Load

Miller (1956) was among the first psychologists to acknowledge the limits of our working memory, suggesting that there is only so much information we can attend to as we actively engage in cognitive processing. According to Chandler and Sweller's (1991) *cognitive load theory*, any channel is limited in the amount of cognitive processing that occurs at any given time. If we are observing something through a visual channel, for example, our resources are divided among interpreting physical representations (i.e., what we see in front of us) and accessing related memory representations, such as our previous experience with those representations (Mayer & Moreno, 2003). When we must generate a stimulus, such as through visualization, we must simultaneously access our deep working memory representations (e.g., visual models) to facilitate the creation of those images, access our related memory representations, and also interpret the representations that we are generating (Mayer & Moreno, 2003). Thus, having the cognitive responsibility of simultaneously generating these images may result in cognitive overload, or the point at which needed cognitive processing exceeds the individual's capacity to process (Chandler & Sweller, 1991).

Thus, one major drawback to mental imagery and mental practice is the amount of cognitive effort required. Participants must actively combat other intervening thoughts, remain focused on the imagery task, and effectively render it in their minds. Visualization thus requires a great deal of cognitive effort, which may explain why it is not always successful (Kosslyn et al., 2006). Ginns, Chandler, and Sweller (2003) found that when students had to imagine novel scenarios, it was more effective for them to absorb that knowledge visually; students who imagined the scenarios learned significantly less than those who learned through a visual channel, likely because of the cognitive effort exerted in trying to visualize. Babin and Burns (1998) suggest that part of this cognitive load may come from imagery elaboration, wherein effort is expended to associate the information in the mental stimulus with other information in long-term memory. Because the imager is simultaneously trying to render the image and remain engaged with it while summoning the schematic information associated with the rendered image, cognitive overload may occur. Participants may resort to solely focusing on the image, shutting down elaboration, or elaborate, which takes away cognitive resources from the imaging effort. Mediated stimuli do not require such a tradeoff because participants to not have to actively render those images; however, features of mediated messages may still create cognitive overload (Lang, 2000).

The *limited-capacity information-processing model* (Lang, 1995, 2000) suggests that media observers are equipped with limited cognitive resources to handle mediated messages, and that media messages are comprised with many elements that elicit automatic cognitive responses from observers. Several factors contribute to the overall cognitive load of a message or image, including the number of features in the message as well as the amount of information that is not provided in the message or implied (i.e., what must be filled in by the receiver; Kosslyn et al., 2006; Lang, 1995, 2000). The model argues that different media elicit different responses due to different channels (e.g., radio is restricted to audio whereas television features audio and visual information) and features, and tests of the model have been conducted across radio (Lang, Schwartz, Lee, & Angelini, 2007; Potter, 2000), television (Geiger & Reeves, 1993; Lang, Geiger, Strickwerda, & Sumner, 1993; Lang, Newhagen, & Reeves, 1996; Lang, Bolls, Potter, & Kawahara, 1999) and the Internet (Lang, Borse, Wise, & David, 2002).

No work was identified that has tested the model within virtual environments; however, logical conclusions may be drawn on the similarities of the stimuli within the VE. These studies demonstrate that cognitive overload tends to happen when a stimulus requires maximal attention or cognitive effort to process. Although many stimulus features, including movement, novelty, or change, yield an immediate orienting response upon their introduction, this arousal wanes as the person adjusts to the stimulus, usually within three to seven seconds (Reeves, Lang, Kim, & Tatar, 1999; Reeves & Nass, 1996). Once participants have acclimated to the message, barring novel or emotional content, participants experience less arousal and exert less cognitive effort (Lang, 2000; Lang et al., 2007). The stimuli used in these studies have been limited to the visual channel; no other sensory channels are incorporated. Thus, while there is potential for cognitive overload during the orientation response to the stimulus within the virtual environment, it is anticipated that after the observer has acclimated, no additional cognitive strain would occur if the stimulus remains steady. Thus, participants can attend to the stimulus and the message can be fully processed, achieving maximal effects.

In contrast, a visualization task requires constant cognitive effort, perhaps to the point of overload. The images must be generated, maintained, and attended to simultaneously. Having to devote so many cognitive resources to this process may hamper learning and thus limit the effects of the message, as Ginns et al. (2003) found. Research also indicates that the ability to create mental imagery varies among individuals (Hall & Martin, 1997), so these tasks may not be effective treatments for those who have difficulty visualizing. In contrast to the effortful nature of mental practice, a virtual stimulus requires less cognitive labor. Thus, virtual environments may have an advantage over the use of mental practice to promote healthy behavior, especially among those individuals who have difficulty conjuring mental images on demand. Currently, however, no studies have addressed the comparison of the two stimuli in the health domain.

Thus, we would anticipate differences between a visual virtual environment, in which the scene is rendered before the individual's eyes, and a mentally-imaged environment that the individual must generate. To respond to these unanswered questions, an exploratory study comparing the two stimuli was designed. Given that no previous research has compared these two stimulus types in the domain of behavior modeling, the study was framed to gather as much information as possible on potential differences. Additionally, this study sought to extend the work of Study 1 and, in this case, examine participants pre-existing self-efficacy regarding an exercise behavior before the administration of any treatment, thus enabling a comparison on the potential impact on both self-efficacy and exercise. The following hypotheses and research questions are proposed:

H4: Participants who receive a VE stimulus will show a greater increase in their estimated pushup ability than participants who receive an MP stimulus.

RQ3: Will pre-existing self-efficacy interact with stimulus type to affect changes in estimated pushup ability?

H5: Participants who receive a VE stimulus will demonstrate higher levels of specific self-efficacy than those who receive an MP stimulus.

RQ4: Will pre-existing self-efficacy interact with stimulus type to affect specific self-efficacy?

H6: Participants who receive a VE stimulus will show a greater increase in actual pushup performance than participants who receive an MP stimulus.

RQ5: Will pre-existing self-efficacy interact with stimulus type to affect changes in actual pushup performance?

No relevant research was identified regarding the comparison of psychological effects of encountering the self within imagined and virtual environments. Imagining oneself, which is a common occurrence when we recall memories or daydream, and encountering a three-dimensional virtual representation of oneself, which is likely a rare if not novel event, are clearly two distinct experiences. Thus, no specific predictions were made and exploratory research questions were proposed regarding perceived resemblance, identification, and presence.

RQ6: Will there be a difference in perceived resemblance across conditions?

RQ7: Will there be a difference in identification across conditions?

RQ8: Will there be a difference in presence across conditions?

Method

Sample

A convenience sample was obtained from the student population of a medium-sized West Coast university. The sample (N = 91) consisted of 57 women and 34 men aged 18 to 53 (M = 20.89, SD = 5.15). Participants self-reported their race/ethnicity as Caucasian/European-American/White (45.1%; n = 41); African/African-American/Black (9.9%; n = 9); Latino/a (16.5%; n = 15); Asian/Asian-American (18.7%; n = 17); Pacific Islander (1.4%; n = 1); and Other or multiple races/ethnicities (8.8%; n = 8).

Design

A between-subjects design was employed for this experiment. Participants were randomly assigned to either a *Virtual Environment* (VE) or *Mental Practice* (MP) stimulus. Participants' responses on the pretest determined whether they were categorized as low or high self-efficacy. If participants indicated they "probably" or "definitely" could not perform the number of pushups in the stimulus (30 for women and 60 for men), they were categorized as low self-efficacy; all others were categorized as high self-efficacy. Participants were randomly assigned to either the VR or MP treatment. Thus, there were four conditions for analysis: VE-High SE (*n* = 19), VR-Low SE (*n* = 24), MP-High SE (*n* = 17), and MP-Low SE (*n* = 31).

Procedure

To determine the number of pushups for the stimulus, a pilot survey was conducted using a class pool (*N* = 66; 20 men and 46 women). Participants were asked to time themselves completing as many pushups as possible in one minute, and then respond to ten items on a 5-point scale (1 = *Definitely could not do it*; 5 = *Definitely could do it*) whether or not they felt they could complete a certain number of pushups in one minute (5, 10, 15, 20, 25, 30, 40, 50, 60, more than 60). Scatterplots of these responses were then examined to determine a clear and appropriate cut-off point for each of the sexes. It was determined that 30 pushups for women and 60 pushups for men created a clear split for each group; that is, nearly half of the participants indicated they "definitely" or "probably" could not do it, and nearly half indicated they "definitely" or "probably" could.

Participants in this study appeared for a photo session wherein they had their photographs taken with a digital camera and later their virtual head models were constructed as they had been in all studies. Approximately one week before their experiment was scheduled, participants were sent an email with a link to a pretest. As in the pilot survey, the experimental pretest asked them to rank their confidence in performing specific numbers of pushups in one minute. Participants also completed an assessment of their mental imagery ability at that time.

In the mental practice condition, participants were asked to stand in the experimental room. Low self-efficacy participants were given the following instructions:

> For this task, you're going to be imagining a room that resembles this lab. Inside that room, you will imagine your physical self. You will be looking at yourself from the 3rd person, as if looking at a photograph of yourself. The person you will imagine in the room is a mental image of you.
>
> While imagining this world, you are going to envision your self performing an exercise, pushups. Your self will be performing 30 pushups [for women; 60 for men] in one minute. When we asked you earlier, you indicated that you are unable to perform 30 pushups [for women; 60 for men] in one minute. Your task will be to imagine yourself successfully perform pushups at a rate that you cannot perform in the real world.

The instructions for high self-efficacy participants were the same, except the last sentences read:

> When we asked you earlier, you indicated that you are able to perform 30 pushups [for women; 60 for men] in one minute. Your task will be to imagine yourself successfully perform pushups at a rate that you can perform in the real world.

Next, participants were instructed to look around the room for 30 seconds to familiarize themselves with the setting. The experimenter timed this phase and let them know when 30 seconds had transpired. Then, participants were instructed to close their eyes and spend 60 seconds simply imagining themselves standing in the room from the third person. The experimenter kept time and told the participants when to stop. In the final phase, participants were instructed to close their eyes and spend 60 seconds imagining themselves successfully completing 30 (for women) or 60 (for men) pushups. Women were told this was approximately one pushup every two seconds; men were told this was one pushup each second. Afterward, participants were instructed to complete some measures on the computer.

In the virtual environment condition, participants stood at the same point in the experimental room as the MP participants. They were given the following instructions:

> For this task, you're going to be put in a room that resembles the actual lab. Inside that room, you are going to see a virtual human. This isn't a real person—it is a virtual person we have created in the virtual lab. This virtual human was built to look like you. We took the photographs you took earlier and used them to build this virtual representation of you. The person you will see in the room is a virtual copy of you.
>
> While inside the virtual world, you are going to see your avatar performing an exercise, pushups. Your avatar will be performing 30 [for women; 60 for men] pushups in one minute. When we asked you earlier, you indicated that you are unable to perform 30 [for women; 60 for men] pushups in one minute. Your task while in the virtual world will be to watch your avatar successfully perform pushups at a rate that you cannot perform in the real world.

Again, high self-efficacy participants were given the same prompt, except that the last two sentences read:

> When we asked you earlier, you indicated that you are able to perform 30 pushups [for women; 60 for men] in one minute. Your task while in the virtual world will be to watch your avatar successfully perform pushups at a rate that you can perform in the real world.

Then, participants were outfitted in the head-mounted display. The room was rendered in front of them from the same perspective. Next, they were instructed to look around the room for 30 seconds to familiarize themselves with the setting. The experimenter timed this phase and let them know when 30 seconds had transpired. Then, participants were timed as they spent 60 seconds looking at their virtual self-representation standing in the room across from them (i.e., in the third person). The experimenter kept time and told the participants when to stop. In the final phase, participants watched as the virtual self successfully completed 30 pushups (women) or 60 pushups (men) in 60 seconds. See

Figure 15 for examples of the virtual stimuli. Afterwards, participants were taken out of the equipment and instructed to fill out measures on the computer.

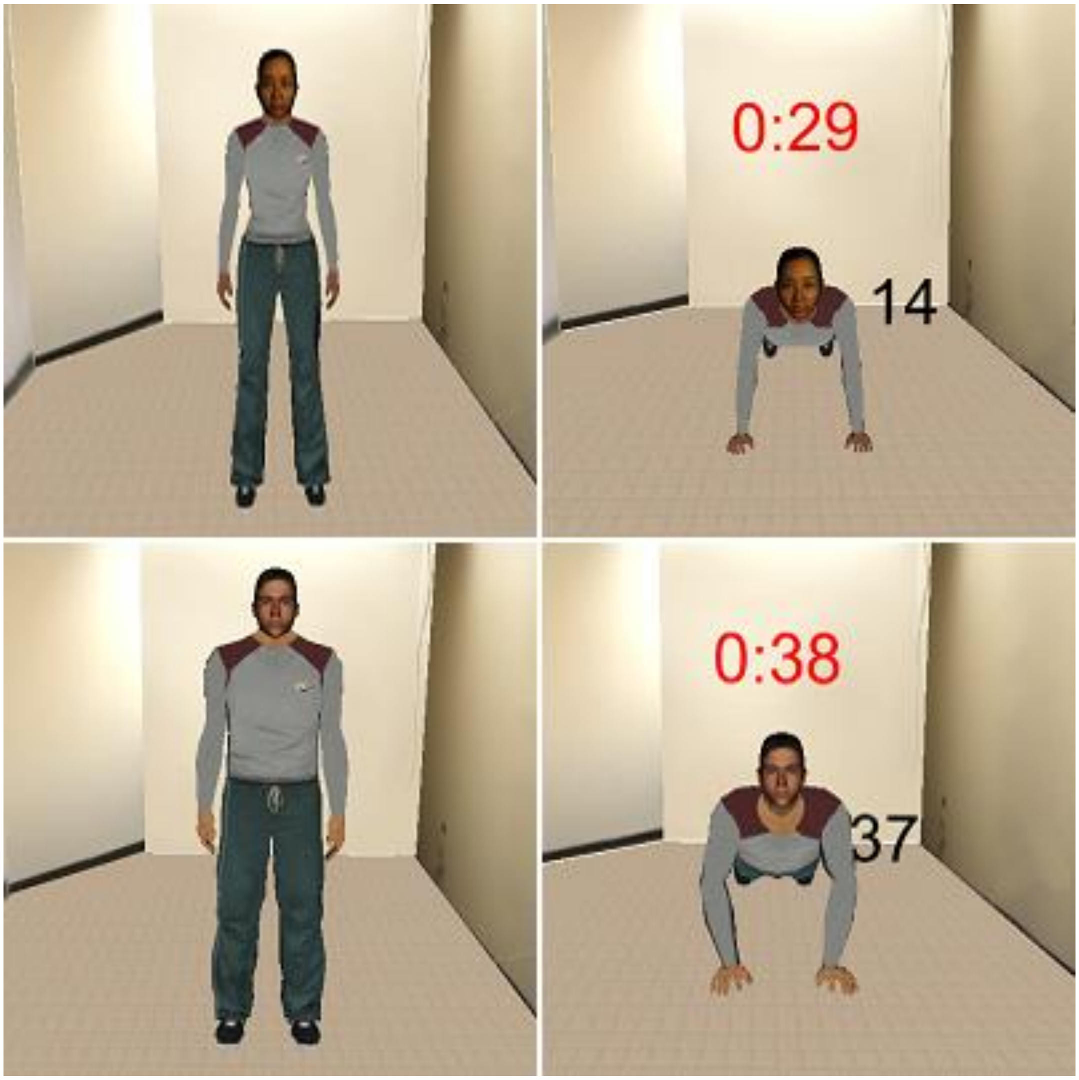

Figure 15. Example stimuli from Study 2. Participants observed their virtual selves standing for one minute (left) before observing them perform pushups successfully (right). Numbers to the right of the virtual self counted off the number of pushups as a stopwatch (at top) kept time.

At this point, both groups completed measures indicating their level of self-efficacy regarding the pushup exercise. Once they completed this part of the survey, the exercise phase commenced. The experimenter verbally explained proper pushup technique and then demonstrated once for the participant. After making sure the participant understood proper form, the experimenter led the participant back to the experimental room. Participants were then instructed:

> I am going to ask you to perform as many pushups as you can in one minute while maintaining proper form. If you wish, you can pause and rest in between exercises. If you experience any pain aside from regular muscle exertion, please let me know and do not continue. The goal is to perform as many pushups as possible in one minute while maintaining good form. If you start to lose your form and do not complete the exercise properly, I will let you know; those repetitions will not count. I will count out loud so you know how many pushups you have completed, and help you keep track of time by telling you when you've reached 30 seconds, the halfway point.

The experimenter asked the participant to get in position and then started the timer as the participant began. Only pushups completed with proper form were counted; if participants' form was not acceptable, the experimenter offered corrective feedback (e.g., "You have to bend your elbows and go further down") and did not count that repetition. After one minute, the experimenter informed the participant that the exercise phase was complete, and participants returned to the computer to complete the rest of the survey measures.

Pretest Measures

Time 1 pushups. Participants were instructed on proper pushup form. Next, they were asked to time themselves for one minute and complete as many pushups as possible. Participants reported completing between 0 and 63 pushups (*M* = 23.30, *SD* = 15.50). This item was self-reported.

Time 1 pushup self-efficacy. After completing the pushup task, participants were asked to respond to twelve items to determine their confidence levels in performing a certain number of pushups (ranging from 5 to more than 80) in one minute. Participants indicated on a 5-point scale (1 = *Definitely could not do it*; 5 = *Definitely could do it*) whether they felt they could perform that number of pushups in one minute. This data was used to divide participants into low and high self-efficacy groups.

Experiment Measures

Time 2 estimated pushups. Upon arrival for the experiment, participants were asked to estimate how many pushups they felt they could complete in one minute (M = 19.86, SD = 13.63).

Resemblance. Participants were asked to indicate on a 5-point scale (1 = *Not at all*; 5 = *Extremely*) the degree to which they believed the representation (avatar in VR conditions or imagined self in MI conditions) resembled them in the face, the body, and overall (M = 3.09, SD = 1.01). Reliability for this measure was Cronbach's α = .85.

Identification. The same items as Study 1 were used to assess identification. Scores ranged from 1.00 to 5.00 (M = 3.05, SD = .91). A Cronbach's alpha of α = .85 was achieved.

Presence. The same measure as Study 1 was used to assess presence. Scores ranged from 1.00 to 5.00 (M = 2.72; SD = .68). A Cronbach's alpha of α = .86 was achieved.

Specific exercise self-efficacy. The same items used in Study 1 were adapted to assess participants' self-efficacy towards the specific exercise demonstrated by the virtual model, pushups. Participants indicated on a five-point scale (1 = *Strongly disagree*; 5 = *Strongly agree*) their agreement with statements including "I would be successful in performing pushups at the pace I saw" and "I would have no problems performing pushups at the pace I saw." Responses were averaged; scores ranged from 1.00 to 4.43 (M = 2.22; SD = .93). A Cronbach's alpha of α = .94 was achieved.

Time 3 estimated pushups. After exposure to the treatment but before they completed any exercises, participants were asked again how many pushups they believed they could complete in sixty seconds. This estimate was taken to compare to the Time 2 estimate that participants provided before the treatment.

Time 3 pushups. At the time of the experiment, a research assistant counted each pushup participants performed with proper form in sixty seconds during the exercise phase. The number of performed ranged from 0 to 67 (M = 27.62; SD = 16.44).

Results

Because of a) the difference in sample sizes and individual cell sizes between men and women; b) the difference in stimuli; and c) the difference in men's and women's upper body strength and the ability to perform pushups, men and women were analyzed separately. Factorial ANOVAs were conducted to examine the effects of stimulus and pre-existing self-efficacy for each sex. Levene's tests were run to test for equality in variance given the inequal cell sizes; variances were equal unless otherwise noted.

The means and standard deviations for all dependent variables can be seen in Table 5.

Table 5

Study 2 Means and Standard Deviations for Dependent Variables by Condition and Sex

Condition	DV	T1 Pushups		T2 Est. Pushups		Specific SE		T3 Est. Pushups		T3 Pushups	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
VE Low		24.31	15.29	20.18	14.35	2.14	.70	25.56	17.27	26.63	16.10
	Men	34.00	7.45	31.50	6.99	2.39	.80	36.30	11.00	37.77	12.15
	Women	8.17	10.05	6.60	6.72	1.84	.43	7.67	7.89	13.46	8.15
VE High		35.39	16.75	32.65	14.59	3.74	1.10	36.39	17.89	42.21	16.23
	Men	48.50	14.54	44.29	15.39	3.77	1.06	50.83	16.56	56.75	14.60
	Women	24.14	8.09	24.50	6.43	3.71	1.19	24.00	4.87	31.64	5.71
MP Low		17.13	13.51	15.47	12.07	1.82	.88	15.80	12.28	23.07	15.36
	Men	34.33	6.63	31.44	5.20	1.92	.80	31.56	6.29	43.44	7.07
	Women	9.76	7.53	8.62	6.01	1.78	.93	9.05	6.58	14.73	8.21
MP High		37.33	16.19	30.47	15.23	3.45	.89	33.42	16.00	35.77	13.11
	Men	57.00	8.71	45.00	19.15	3.50	.92	50.50	12.15	52.75	14.08
	Women	27.50	6.91	25.18	9.97	3.43	.93	24.88	9.42	30.54	7.34
Overall		25.51	16.95	22.86	15.33	2.61	1.20	24.75	17.15	30.37	16.89

Table 5 (continued)

Study 2 Means and Standard Deviations for Dependent Variables by Condition and Sex

Condition	DV	Resemblance *M*	Resemblance *SD*	Identification *M*	Identification *SD*	Presence *M*	Presence *SD*
VE Low		2.31	.77	2.34	.82	2.35	.62
	Men	2.49	.57	2.48	.82	2.57	.62
	Women	2.09	.93	2.18	.83	2.09	.54
VE High		2.74	.59	2.80	.52	2.58	.44
	Men	2.50	.71	2.80	.53	2.72	.31
	Women	2.91	.45	2.80	.54	2.49	.51
MP Low		3.67	.78	3.55	.68	2.98	.53
	Men	3.37	.42	3.51	.56	2.87	.31
	Women	3.79	.86	3.56	.73	3.03	.59
MP High		4.12	.82	3.63	.81	2.91	1.02
	Men	3.33	.90	2.94	.90	2.09	.86
	Women	4.36	.66	3.85	.68	3.16	.96
Overall		3.20	1.02	3.09	.89	2.71	.70

Hypotheses

Estimated pushups. H4 proposed that a VE treatment would be more effective than an MP treatment in increasing participants' estimates of how many pushups they could perform, and RQ3 inquired about the role of pre-existing self-efficacy. First, a 2 by 2 ANOVA was performed to determine whether or not there were existing differences between the treatment groups. Although a significant difference was expected between low and high self-efficacy participants, no differences should exist between the VE and MP treatments, which would indicate that assignment across groups was not equal. Results indicated that although there was a difference in Time 2 estimated pushups between high (M = 24.86, SD = 8.27) and low (M = 7.97, SD = 6.21) self-efficacy participants, $F(1, 48) = 67.48$, $p < .0005$, partial $\eta^2 = .58$, there was no significant difference between the MP (M = 14.31, SD = 10.92) and VE (M = 15.55, SD = 11.19) groups, $F(1, 48) = .41$, $p > .05$, partial $\eta^2 = .01$, nor was there an interaction effect, $F(1, 48) = .10$, $p > .05$, partial $\eta^2 = .00$.

A mixed design ANOVA was then performed with treatment and pre-existing self-efficacy as between-subjects variables and participants' Time 2 and Time 3 estimated pushups as the within-subjects variables.[6] Overall, women demonstrated a significant increase between Time 2 (M = 13.71, SD = 10.31) and Time 3 (M = 14.36, SD = 10.28) estimations, $F(1, 38) = 7.60$, $p < .01$, partial $\eta^2 = .17$. There was also an effect of treatment wherein those in the VE condition experienced a greater increase in their estimated pushup ability after treatment than those in the MP condition, $F(1, 38) = 7.10$, $p = .01$, partial $\eta^2 = .16$. There were no differences between low and high self-efficacy participants over time, $F(1, 38) = .06$, $p > .05$, partial $\eta^2 = .00$, nor was there an interaction effect of treatment and self-efficacy over time, $F(1, 38) = 1.27$, $p > .05$, partial $\eta^2 = .03$. Figure 16 depicts these results.

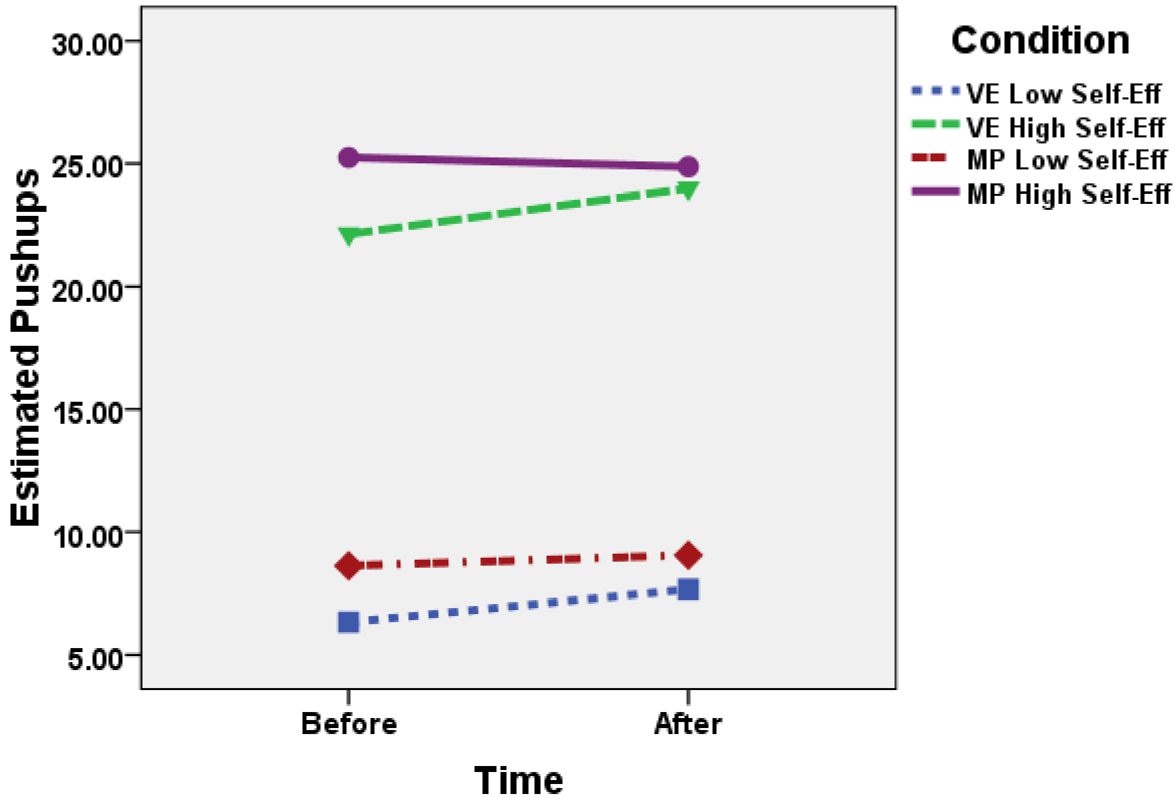

Figure 16. Women's estimated pushups before and after treatment.

For men, the only significant effect was an increase between estimations at Time 2 ($M = 36.24$, $SD = 11.98$) and Time 3 ($M = 39.79$, $SD = 13.55$), $F(1, 25) = 7.62$, $p = .01$, partial $\eta^2 = .23$. There were no effects for treatment, $F(1, 23) = .80$, $p > .05$, partial $\eta^2 = .03$, self-efficacy, $F(1, 23) = 2.44$, $p > .05$, partial $\eta^2 = .09$, or an interaction, $F(1, 23) = .05$, $p > .05$, partial $\eta^2 = .00$.

Specific self-efficacy. H5 suggested that the VE stimulus would increase participants' self-reported specific self-efficacy more than the MP treatment, and RQ4 questioned whether pre-existing self-efficacy would interact with the stimulus type. For women, there were no differences between VE and MP treatments, $F(1, 53) = .48$,

$p > .05$, partial $\eta^2 = .01$, nor was the interaction effect significant, $F(1, 53) = .19$, $p > .05$, partial $\eta^2 = .00$. Only the main effect for pre-existing self-efficacy was significant; unsurprisingly, high self-efficacy women reported greater feelings of self-efficacy than low self-efficacy women, $F(1, 53) = 48.55$, $p < .0005$, partial $\eta^2 = .48$. For men, the same pattern was found; there were no differences between VE and MP treatments, $F(1, 30) = 1.24$, $p > .05$, partial $\eta^2 = .04$, nor was the interaction effect significant, $F(1, 30) = .09$, $p > .05$, partial $\eta^2 = .00$. Only the main effect for pre-existing self-efficacy was significant; high self-efficacy men reported greater feelings of self-efficacy than low self-efficacy men, $F(1, 30) = 20.28$, $p < .0005$, partial $\eta^2 = .40$.

Actual pushups. H6 predicted that participants receiving the VE treatment would have greater increase in actual pushup performance over participants who received the MP treatment; RQ5 questioned the role of pre-existing self-efficacy. A repeated-measures ANOVA was performed to assess changes before and after the treatment.[7] For women, the only significant effect was an increase in pushups performed from Time 1 ($M = 15.31$, $SD = 11.10$) to Time 3 ($M = 19.02$, $SD = 10.39$), $F(1, 38) = 12.99$, $p = .001$, partial $\eta^2 = .26$. There were no effects for treatment type, $F(1, 38) = 1.28$, $p > .05$, partial $\eta^2 = .03$, self-efficacy, $F(1, 38) = .07$, $p > .05$, partial $\eta^2 = .00$, or an interaction, $F(1, 38) = 1.81$, $p > .05$, partial $\eta^2 = .05$. For men, the only significant effect was an increase in actual pushups performed from Time 1 ($M = 40.28$, $SD = 12.50$) to Time 3 ($M = 46.14$, $SD = 13.30$), $F(1, 25) = 6.08$, $p < .05$, partial $\eta^2 = .20$. There were no effects for treatment, $F(1, 25) = 1.33$, $p > .05$, partial $\eta^2 = .05$ or self-efficacy, $F(1, 25) = 2.67$, $p > .05$, partial $\eta^2 = .10$. The interaction bordered on significance, $F(1, 25) = 3.87$, $p = .06$, partial $\eta^2 = .13$. The general trend was that participants experienced greater performance in all conditions except the high self-efficacy MP group, which declined. However, the Levene's test was significant for the between-subjects factor, and given the small and unequal cell sizes, this finding must be considered with caution.

Resemblance. RQ6 inquired about potential differences in perceived resemblance across conditions. For women, there were main effects for resemblance, but no interaction effect. Women in the MP condition believed their self-representation resembled them more than women in the VE condition, $F(1, 53) = 54.99$, $p < .0005$, partial $\eta^2 = .51$. High self-efficacy women reported higher levels of resemblance than low self-efficacy women, $F(1, 53) = 10.72$, $p < .005$, partial $\eta^2 = .17$, as can be seen in Figure 17. There was no interaction effect, $F(1, 53) = .21$, $p > .05$, partial $\eta^2 = .01$.

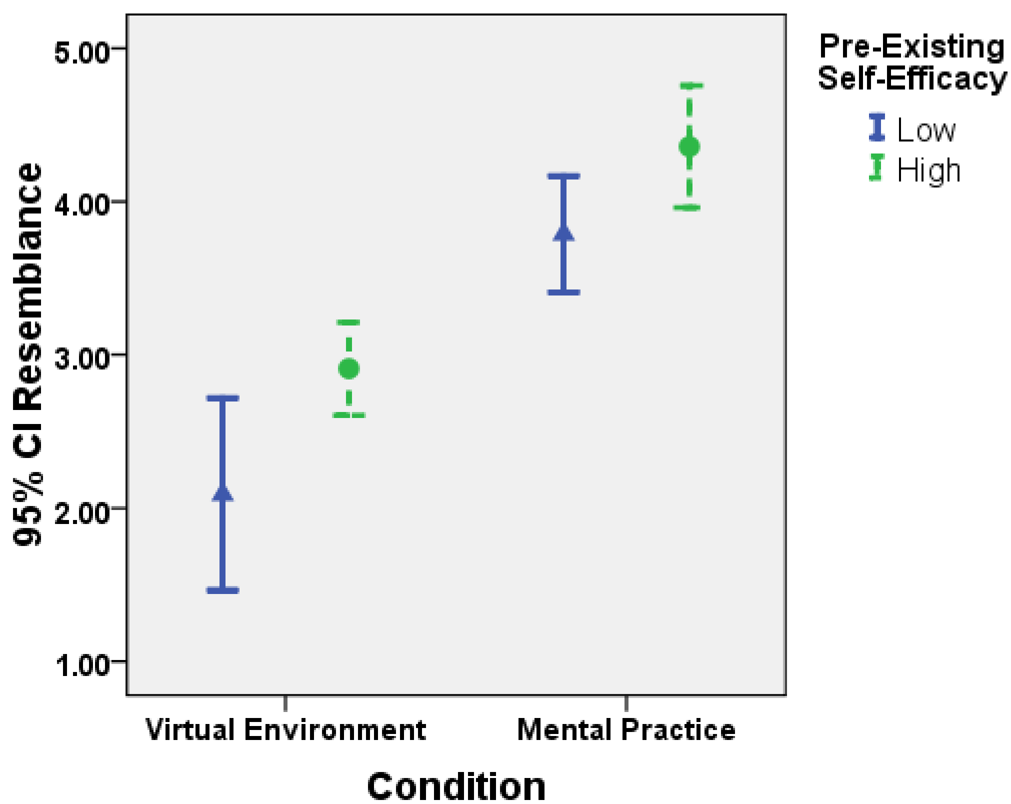

Figure 17. Women's perceived resemblance by Condition.

For men, only the main effect for stimulus was significant. Men in the MP condition (M = 3.36, SD = .57) reported their self-representations resembled them more than men in the VE condition (M = 2.49, SD = .61), $F(1, 30) = 5.23$, $p = .001$, partial $\eta^2 = .32$, as seen in Figure 18. There were no differences between high self-efficacy (M = 2.78, SD = .85) and low self-efficacy (M = 2.85, SD = .67) men, $F(1, 30) = .00$, $p > .05$, partial $\eta^2 = .00$, nor was the interaction effect significant, $F(1, 30) = .01$, $p > .05$, partial $\eta^2 = .00$.

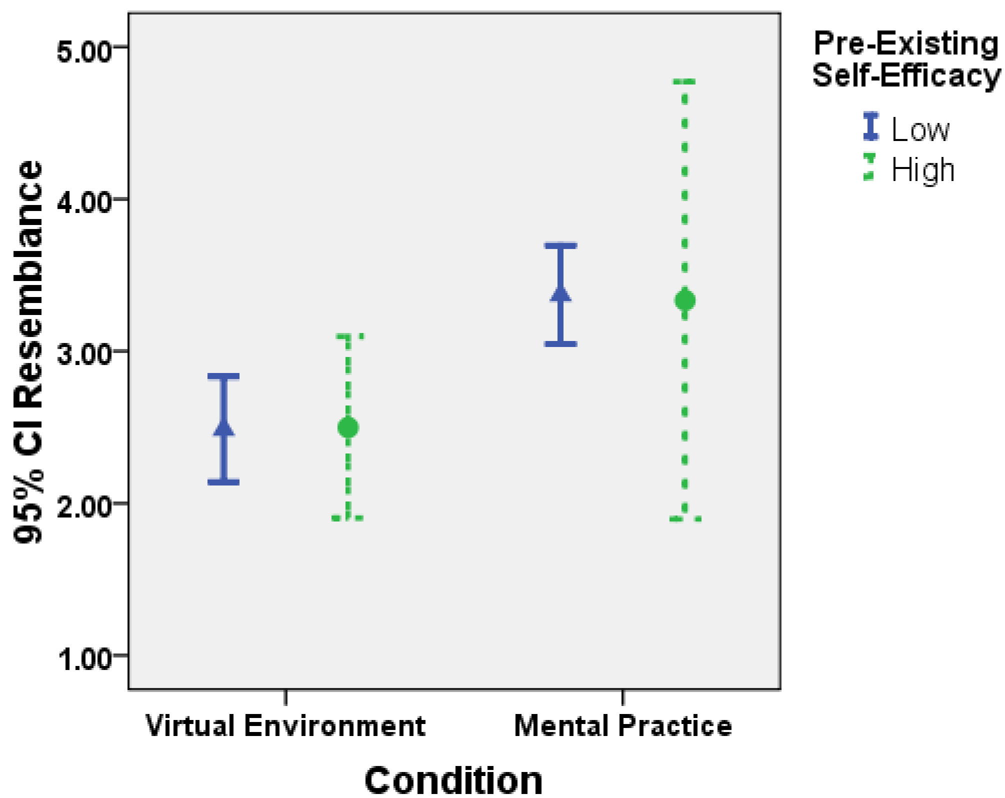

Figure 18. Men's perceived resemblance by Condition.

Identification. RQ7 addressed identification. Again, for women, both main effects were significant but the interaction was not. Women in the MP condition identified significantly more with their self-representation than women in the VE condition, $F(1, 53) = 38.84$, $p < .0005$, partial $\eta^2 = .42$. High self-efficacy women experienced significantly more identification than low self-efficacy women, $F(1, 53) = 5.29$, $p < .05$, partial $\eta^2 = .09$. The interaction effect was not significant, $F(1, 53) = .21$, $p > .05$, partial $\eta^2 = .01$. See Figure 19.

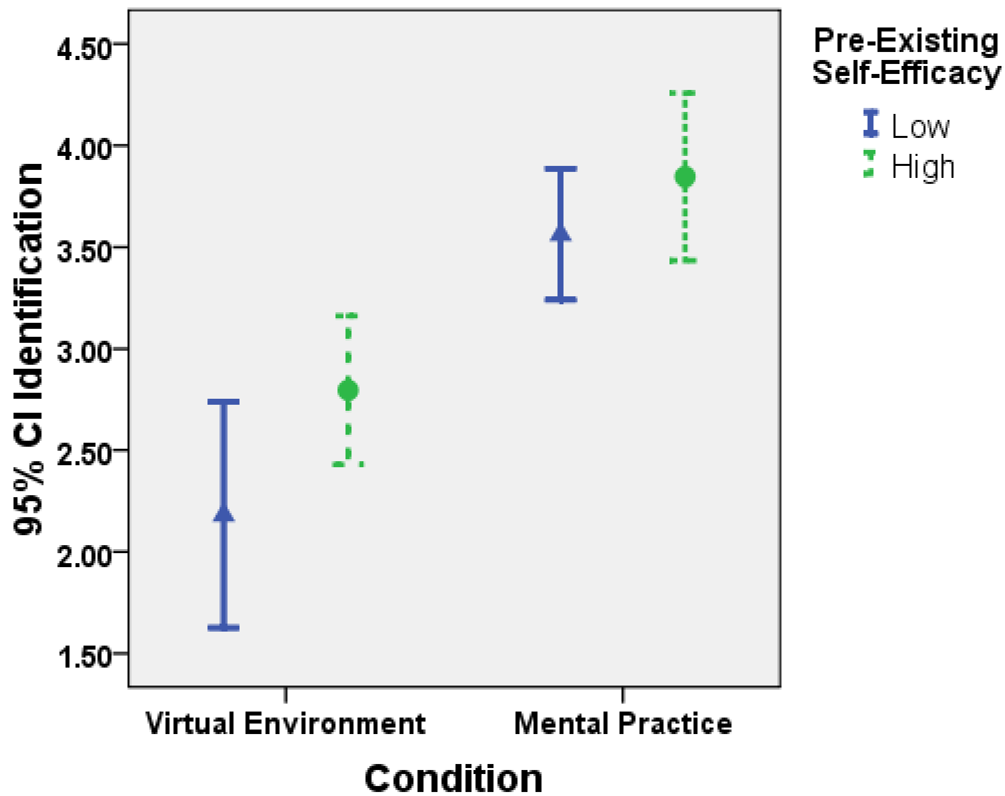

Figure 19. Women's identification by Condition.

For men, only the main effect for stimulus was significant. Men in the MP condition reported greater feelings of identification than men in the VE condition, $F(1, 30) = 4.91$, $p < .05$, partial $\eta^2 = .14$. There were no differences between high self-efficacy and low self-efficacy men, $F(1, 30) = .24$, $p > .05$, partial $\eta^2 = .01$, nor was the interaction effect significant, $F(1, 30) = 2.84$, $p = .10$, partial $\eta^2 = .09$; see Figure 20.

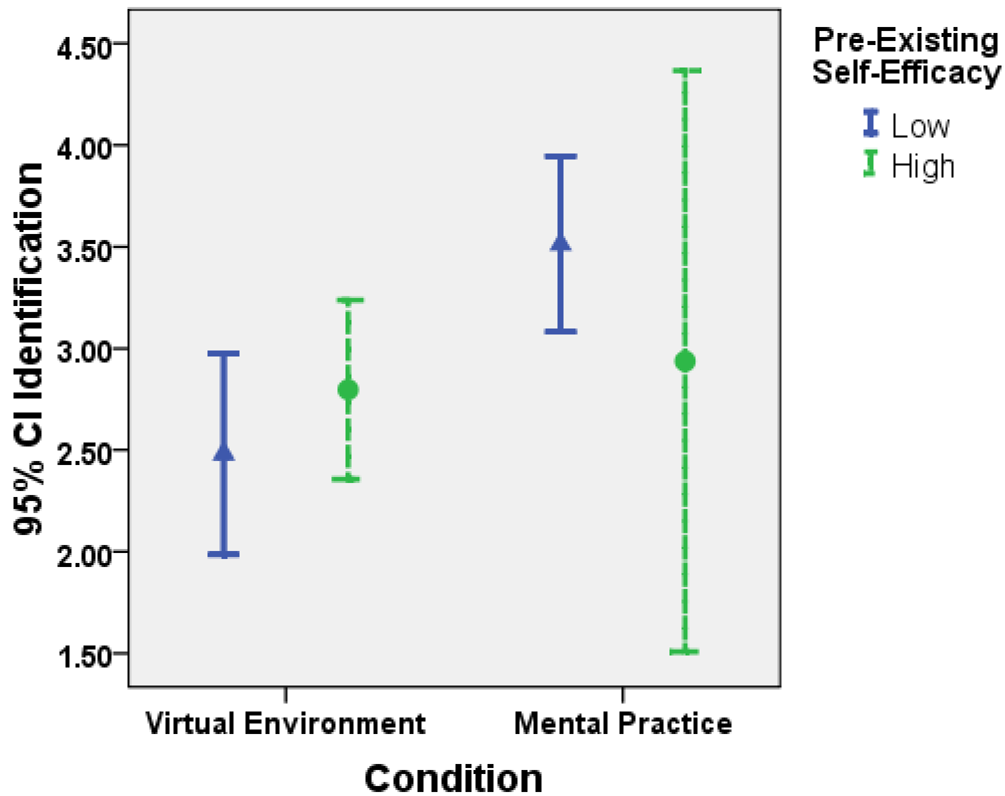

Figure 20. Men's identification by Condition.

Presence.[5] RQ8 addressed presence. For women, only the main effect for stimulus was significant. Women in the MP condition (M = 3.08, SD = .74) reported greater feelings of presence than women in the VE condition (M = 2.29, SD = .55), $F(1, 53) = 8.49$, $p < .0005$, partial $\eta^2 = .26$. There were no differences between high self-efficacy (M = 2.85, SD = .84) and low self-efficacy (M = 2.71, SD = .72) women, $F(1, 53) = .24$, $p > .05$, partial $\eta^2 = .04$, nor was the interaction effect significant, $F(1, 53) = .50$, $p > .05$, partial $\eta^2 = .01$; see Figure 21.

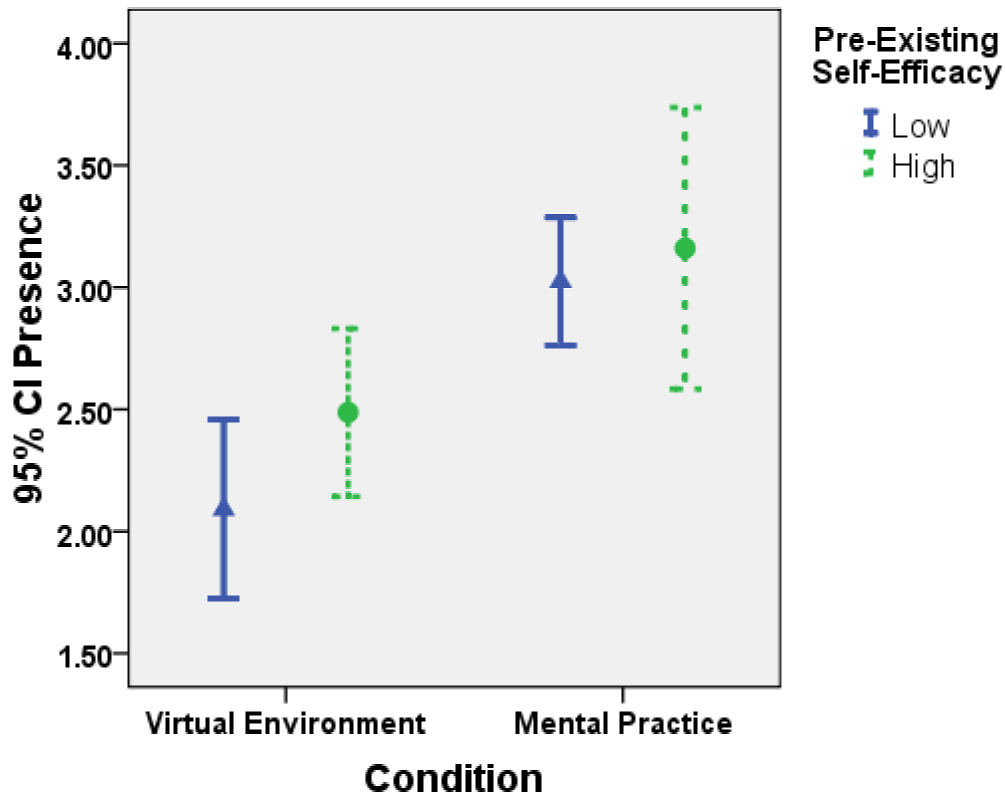

Figure 21. Women's presence by Condition.

For men, neither of the main effects were significant. Men in the MP condition (M = 2.63, SD = .62) did not differ from men in the VE condition (M = 2.62, SD = .52) in feelings of presence, $F(1, 30) = .68$, $p > .05$, partial $\eta^2 = .02$. There were also no differences between high self-efficacy (M = 2.51, SD = .60) and low self-efficacy (M = 2.69, SD = .53) men, $F(1, 30) = 2.56$, $p > .05$, partial $\eta^2 = .08$. The interaction effect was significant, $F(1, 30) = 5.57$, $p < .05$, partial $\eta^2 = .16$. Followup pairwise comparisons with Bonferroni corrections were conducted; a conservative test was chosen given the number of statistical tests run. No significant differences were found between the four groups, however (MP-Low SE, M = 2.87, SD = .31; VR-High SE, M = 2.72, SD = .31; VR-Low SE, M = 2.57, SD = .62; MP-High SE, M = 2.09, SD = .86).

Discussion

This study served as an exploratory examination of the utility of mental imagery as compared to virtual environments as stimuli for behavior change. Overall, there were no differences in behavioral outcomes between conditions; however, men and women both increased the number of pushups achieved after treatment, so it may be that these treatments were equally effective in enhancing exercise performance. One interesting finding is that for women, seeing themselves succeed in the virtual environment was more effective than visualizing their success in boosting the estimated amount of pushups they believed they could perform. In essence, this represents an effective shift in self-efficacy: women in the VE condition experienced more change in their perceived pushup efficacy than women in the MP condition. Men, however, did not experience this change. It may be that because women are generally not as proficient at performing pushups as men, mere visualization was not able to overcome women's perceptions of self-efficacy; however, seeing themselves perform this behavior in a VE did overcome some of their reservations. This demonstrates that VEs may be more effective than mental practice for some groups in promoting health beliefs.

To my knowledge, this is the first study that has attempted to compare the utility of a computer-generated virtual human and an imagined human in achieving a health-related outcome, although many health treatments incorporate VEs or mental imagery. Several differences were found between conditions on variables that have played a role in previous studies, such as resemblance, identification, and presence, and these findings should help guide the design of future experiments comparing virtual and imagined stimuli. It is unsurprising that there were differences in resemblance between the mental practice and virtual environment conditions; due to limits on the technology, virtual humans can only resemble the self so closely, and situational variables may influence differences in appearance (e.g., what clothes a person is wearing or the way hair is styled). In mental imagery it is easier to generate an identical representation of the self. Participants also experienced more identification with their representations in the mental practice condition. It may be that conjuring an image of oneself is a familiar experience, like daydreaming, in which one projects the self into an imagined world. Thus, identification may be felt more readily when visualizing. In this virtual environment, participants had no control over the image; they were merely passive observers, which also may have hindered their feelings of identification with the virtual self. Future research should investigate whether these variables play a role in behavioral outcomes, and if so, what steps can be taken for virtual environments to achieve levels similar to those of mental imagery.

For presence, it was interesting that only women experienced a difference between mental imagery and the virtual environment; men experienced equal levels of immersion and engagement in both conditions. Previous research has noted sex differences in presence within virtual environments (Nowak et al., 2008). These differences may be explained by the fact that men play considerably more video games than women, and women may be less interested and less likely to be engaged in virtual environments as a result. It is worth noting, however, that VEs were more effective than mental practice in promoting women's self-efficacy, so it is possible that the experience and effects of presence is different for women. Future research should consider both sex and experience with virtual environments such as video games when considering presence as a factor.

One issue with this study was that there was no true control without treatment to compare the effects of VE and MP. Both men and women experienced increases in pushup performance between Time 1 and Time 3 as well as estimated performance before and after the stimulus, but without a control condition these results could be contributed to 1) the tendency to underestimate performance initially so as to not appear to fail; or 2) a mere presence effect, wherein the presence of the experimenter motivated participants to exert more effort and exercise harder than they did on their own in the pretest. Additionally, because participants performed pushups before coming into the lab for the experiment, a certain sensitization must be considered; participants may have performed better at Time 3 simply from having done the exercise at Time 1. Thus, no conclusions can be drawn about the effectiveness of either of these treatments without replication.

CHAPTER TWELVE: CONCLUSION

Summary of Findings

Study 1 confirmed previous studies' findings and revealed a mechanism behind the effectiveness of virtual selves. When observers feel that a virtual self resembles them physically, they experience more identification with the virtual self. Identification then bolsters behavioral modeling. Because a virtual self is more likely to resemble the observer, it is a more potent model than virtual others.

Given that we observed an increase in behavioral modeling based on identification, it is interesting that there was no effect on self-efficacy in Study 1. Identification with a model is often hypothesized to enhance feelings of self-efficacy, which in turn impacts behavior. Study 1 showed that identification and resemblance were unique predictors of behavior, however. It is possible that the self-efficacy measure was not specific enough to the behavior to capture any changes; in Study 2, the specific self-efficacy measure did not vary by treatment, although there were changes in women's estimated exercise performance, which can also be interpreted as a measure of self-efficacy (i.e., belief in one's ability to perform a behavior at a particular level given the situational factors).

Study 2 demonstrated the potential of virtual environments for promoting health behaviors compared to a more traditional method, mental imagery. Given the differences between pretest and posttest measures, there was some evidence that both types of treatment were effective in promoting self-efficacy (as measured by estimated behavioral performance) as well as actual exercise performance. Additionally, VEs were more effective than mental imagery in promoting women's pushup self-efficacy. Study 2 also served an exploratory function, comparing virtual environments to mental imagery on variables that may be relevant to behavioral outcomes such as resemblance, presence, and identification. Future studies should continue to explore the strengths and weaknesses of each of these environments so that maximally effective health promotion stimuli can be created and implemented in behavior change efforts.

Limitations

As mentioned previously, one limitation of these studies is that the body is not modeled to resemble the participant, only the face. Although most participants still identified the body as resembling theirs, future research should incorporate body modeling as well to create the most accurate form of the virtual self.

Beyond the accuracy of the virtual representations, their realism was also not considered as a potential factor. The exercise-related pretests used less realistic and detailed virtual bodies and showed clear effects for virtual selves, whereas the dissertation studies used more realistic bodies, and the effects were diminished or nonexistent. It could be that using less realistic bodies directs more attention to the face and thus participants are more attuned to the self-resemblance, leading to more powerful effects. Another possibility is that with increasing realism of the stimulus, participants become more aware of what is not realistic. With a more cartoonish or unreal body, users may not be as critical of the depiction of exercise or weight gain or loss because their expectations are not as high. With a highly realistic body, their expectations may be very high, and if any other aspects of the VE are mismatched with that level of realism, these discrepancies may stand out and limit the experience of immersion. Determining the role of realism within these treatments is crucial so that designers know where they need or do not need to divert resources and attention.

Study 1 manipulated the race of the model to match or mismatch the participant. Although race/ethnicity has been used to examine the comparative effectiveness of models in previous studies (Anderson & McMillion, 1995; Appiah, 2001; Kalichman et al., 1995; Pitts et al., 1989) and we did not identify a difference in racism across groups in Study 1, its potency should not be ignored. Some research has demonstrated that people react differently to virtual people of a different race (Dotsch & Wigboldus, 2008; Groom et al., 2009; McCall, Blascovich, Young, & Persky, 2009). Also, Whites may have been less sensitive to the matched-race condition because they tend not to identify as part of a specific ethnic group and do not place importance on their racial identity (Jaret & Reitzes, 1999; Phinney, 1992); unfortunately, there were too few participants in Study 1 to perform meaningful comparisons across races and conditions. Further analyses of race should also include a measure of ethnic identification (e.g., Affirmation and Belonging Scale, Phinney, 1992), which has been shown to be a factor in related studies (Appiah, 2001).

Study 2 had an issue with participant discrepancy. A pre-experimental pilot survey conducted with a class participant pool determined that 30 pushups for women and 60 pushups for men would be appropriate to divide participants into high and low self-efficacy groups for analysis. Because this was self-report data, one possibility is that participants merely guessed and overestimated their abilities, which is why our determined cut-off values proved to be too high for subsequent participants. Another consideration is that the class that completed the pre-experimental pilot survey had a large student-athlete population (33% of the pretest respondents indicated playing a sport for Stanford), whereas most of the participants were not run until the following quarter using mostly a paid pool. Given that Stanford is one of the top performing universities athletically as well as academically, it is likely that the second group of participants had considerably lower athletic ability and upper body strength than the pilot group. Despite specific recruitment efforts to identify high self-efficacy participants (e.g., targeting campus gyms for advertising, employing snowball recruitment techniques to garner athletes through various sports teams, advertising specifically for participants with upper body strength), many of those recruited did not appear for their scheduled experiments and thus it was not possible to fill the high self-efficacy cells of the experimental design. (Indeed, only 28% of participants showed up for their experimental timeslots in the last three weeks of the study.) A replication of this study either changing the pushup quotas or incorporating a high self-efficacy population may have brought more compelling results. A final issue is that there were a greater number of women than men who participated in the study. Between a lack of high self-efficacy participants and a limited number of men, some cell sizes were small, giving little power for the statistical analyses to find effects.

Another issue with Study 2 is that the mental imagery task asked that participants imagine themselves from the third person. Perspective plays a role in mental imagery, and first person imaging (conjuring imagery from one's own natural perspective) has been shown to be more effective than third person imaging (conjuring imagery of the self from outside of the body) for some tasks (Hardy & Callow, 1999; White & Hardy, 1995). This fact was considered in the study design, but there was no efficient way to replicate the first-person perspective in the virtual world so that participants could view the virtual self. A virtual mirror would still provide a third-person perspective of the body, even if allegedly from a first-person viewpoint. Pushups from the first-person perspective would have merely shown a virtual floor coming closer to the face and going farther away, a stimulus that would have been disinteresting and possibly nauseating. Additionally, since the design called for observation, the sense of looking down and having one's virtual body engage in exercise but experiencing the disconnect of not actually having one's physical body move may have led to diminished presence and caused participants to feel unsettled and disembodied. Thus, the stimulus was framed from the third person. Future studies can consider creative ways to overcome this in exercise contexts.

Another issue of using mental practice is that there is no way to control what the participant actually envisions. Despite the instructions, it is possible that participants did not follow instructions or that they did not visualize themselves actually succeeding at the task. Imagery of failure has been shown to have a negative impact on motor tasks (Powell, 1973; Woolfolk, Parrish, & Murphy, 1985). Thus, if participants had trouble imagining themselves succeeding at the task, it may have negatively influenced their physical performance. Negativity may have disproportionately affected low self-efficacy participants, who already held beliefs that they could not achieve that level of performance.

Future Directions and Implications

The results of this line of research are compelling, yet they leave many questions unanswered. Why are virtual selves and virtual humans than resemble the self more effective models?

Although the manipulation in Study 1 was not successful, conceptually the arguments were supported, and thus require further exploration. To what degree does a virtual model need to resemble the self to encourage modeling behaviors? A follow up study might employ a morphing software to blend participants' photos at different grades with others' to see if, for example, a model that is 75% similar to the self is more effective than a model that is 50% or 25% comprised of the self. Another study could examine what features are crucial to match to promote modeling. For example, participants may not be influenced whether or not the mouth resembles theirs, but they may require a similar face shape or skin tone. This research could also be used to further inform the development of face modeling software for use in creating self-avatars.

The exercise in Study 2, pushups, may have been too difficult to observe changes. A ceiling effect was observed in that many participants were not able to perform even a single pushup. Study 2 might be effectively re-run using a different exercise variable with more variability in performance such as a treadmill test, cycling, or a step test (Bruce, 1974).

Pretest 4 indicated that in some cases, different virtual representations may actually create different physiological responses. This study examined stationary and exercising selves; various versions of the virtual self should be created and the bodily response studied. Physiological data from the studies where people observed the self and other fattening or slimming would contribute to our understanding of the findings for Pretests 1 and 2 and Studies 1 and 2. It would also be interesting to study how people respond to increasingly photorealistic versions of the self, or virtual selves with more or less of the physical self's features (e.g., by blending or morphing the self with another).

Another interesting comparison would be how people responded to controlling a virtual self as an avatar as opposed to watching a virtual self as an agent controlled by an algorithm. In addition to heart rate and skin conductance, future studies should explore brain imaging techniques such as fMRI (Baumann et al., 2003; Mraz et al., 2003). New studies could help determine how people react physiologically to the virtual self, and whether these reactions are more similar to how they react to computer-generated virtual humans, photographs of the self, or mirror images.

Longitudinal studies regarding the use of virtual selves as persuasive models are also necessary. How long can we expect these modeling effects to last? There may be a point where exposure to a virtual self is no longer compelling. Alternatively, it could be that if treatment is administered over the long-term, it needs to change over time or be framed in a more interesting manner (i.e., as a game, or with other participants) to keep participants engaged so they do not get bored and quit (Madsen, Yen, Wlasiuk, Newman, & Lustig, 2007). Another consideration is that users may experience reactance at the thought of a virtual version of themselves being used to control their behaviors. Discrepancy in the virtual and physical self should also be explored; long-term studies could also examine what happens if the virtual self experiences positive changes and rewards while the physical self adheres to an exercise plan, but does not.

Replications of these studies should also be conducted with different populations. First Lady Michelle Obama recently announced that the focus of her 2010 initiatives would be childhood obesity. Children and adolescents would be optimal groups for future studies given the popularity of video games among this age group. Additionally, child and adult participants of different body types, particularly those deemed overweight or obese, should be recruited. Also, certain groups have been identified as more sedentary or more at risk for the consequences associated with physical activity, such as heart disease and diabetes (King, Castro, Wilcox, Eyler, Sallis, & Brownson, 2000; King, Rejeski, & Buchner, 1998). Certain age or ethnic groups may be targeted for future testing of exercise interventions using virtual selves.

Virtual selves should also be tested outside of fully immersive virtual environments as well as laboratory treatments. Desktop and mobile applications should be developed to test the effectiveness of these treatments in less immersive settings. Also, these extensions would allow for implementation of the stimuli in more naturalistic environments, such as the home, workplace, school, or gym. Future research involving the widespread use of virtual selves as motivators of physical activity should consider how incorporation could be optimized at micro-, meso- and macro-levels of the surrounding environment (King, Stoklos, Talen, Brassington, & Killingsworth, 2002).

Identification, self-efficacy, and vicarious reinforcement were examined in this line of studies, demonstrating that social cognitive theory is a fruitful framework that could continue to inspire permutations of this research. For example, virtual selves could easily enable the illustration of both proximal and distal health goals (Bandura & Schunk, 1981; Gollwitzer & Oettingen, 1998). A morbidly obese individual could see herself after a ten-pound weight loss or after a hundred-pound weight loss. A smoker could compare his appearance five years and twenty years after quitting smoking or continuing to smoke. Future research could examine how effective the portrayal of proximal versus distal goals may be in short-term and long-term treatments. Another use of virtual self-models could be in the self-regulation of an existing health behavior (Bandura, 2005; Karoly, 1993).

These models could be implemented in self-monitoring as reminders to exercise, or as encouragement to maintain an exercise program or, alternatively, discouragement to abandon it (Febbraro & Clum, 1998).

The studies conducted here were framed within the perspective of social cognitive theory, but other perspectives may offer more insight into the mechanisms. Social comparison theory (Festinger, 1954) may play a role in how we interpret virtual selves in contrast to virtual others. The theory suggests we seek social cues from others to determine our own relative success and status and has been used to explain individuals' health attitudes and behaviors (Buunk, Zurriaga, Gonzalez, Terol, & Roig, 2006; Gerrard, Gibbons, Lane, & Stock, 2005; Klein & Cerully, 2007). In these studies, participants may have been engaging with social comparison with the virtual humans. They may have employed upward social comparison with thinner avatars or exercising avatars, because they were exhibiting socially rewarding behaviors, whereas downward social comparison may have occurred with heavier or inactive avatars. These comparison processes may have motivated participants' reactions, particularly when viewing other avatars as opposed to the virtual self.

Self-discrepancy theory (Higgins, 1987) is also a useful framework that could be adopted when examining the effects of virtual selves. The theory suggests that individuals maintain an *actual* self, or who you believe yourself to be; the *ideal* self, or who you or others want to be; and the *ought* self, or who you or others think you should be (Higgins, 1987; Higgins, Roney, Crowe, & Hymes, 1994). This conflict is particularly relevant to the incorporation of healthful behaviors in a normal lifestyle, for example, when the actual self is sedentary and out of shape, but the ideal self is healthy and fit.

Alternatively, the actual self may be a smoker, but the ought self is a nonsmoker because of the risk of cancer and the threat secondhand smoke presents to others. Individuals are motivated by discrepancies between these three versions of the self to make changes in their health attitudes and behaviors to achieve more synchrony and cohesion (Higgins, Vookles, & Tykocinski, 1992). Virtual selves may be used to provide a visual representation of these forms of the self and add incentives for resolving the discrepancies in a healthful manner.

The concept of wishful identification may be included alongside measures of identification in the future (Feilitzen & Linne, 1975; Hoffner, 1996; Hoffner & Buchanan, 2005). People may be differentially influenced by what they can identify with presently and what they desire to be or what they feel they could be in the future. When virtual selves are altered, for example, to lose weight, this construct might be useful in explaining the model's effectiveness. Some thin people, for example, may not experience wishful identification with a slimming model, whereas overweight observers may.

Another explanation is that virtual reality treatments may simply be more entertaining and fun. Beyond keeping users immediately involved, entertainment value may promote identification, presence, and long-term adherence (Vorderer, 2000; Vorderer, Bryant, Pieper, & Weber, 2006; Vorderer, Klimmt, & Ritterfeld, 2004). Future research could explore the utility of creating virtual exercise gaming environments that feature photorealistic virtual selves. Reeves and Read (2010) make a case for the incorporation of gaming and game-like interfaces in the workplace because they promote engagement and healthy competition. Indeed, similar interfaces could be developed for individuals to compete with others in health-based games. For example, individual members of a family could log in to a system and record their exercise and diet and be virtually rewarded for eating the least junk food or getting the most exercise on a given day.

Were these virtual selves to be incorporated into video games or other applications, another factor to be explored is the role of narrative. Narratives have been shown to facilitate *transportation*, or immersion, into a mediated experience (Green & Brock, 2000). Indeed, Schneider, Lang, Shin, and Bradley (2004) reported that providing game players with a story line resulted in greater identification with the character, a greater sense of presence, and higher physiological arousal. Narratives have also been shown to be useful in conveying health-related information (Green, 2006; Morgan, Movius, & Cody, 2009). Dunlop, Wakefield, and Kashima (2008) argue that health narratives may stimulate self-referent emotions, making them particularly effective in conveying risk. Thus, these findings indicate that adding a narrative might promote engagement, arousal, and more thoughts about one's own risk; incorporating a virtual self within the narrative may bolster these experiences. Further investigation should also determine whether a fun, escapist narrative (e.g., you must exercise and train to prepare for an upcoming spy mission) or a realistic narrative (e.g., you must exercise and train for an upcoming marathon) is more engaging and effective for different individuals.

In these studies, virtual selves have been used exclusively as models for exercise and diet. Future investigations could explore the utility of these models in other health domains, including smoking cessation, drug use prevention, safe sex practices, or management of an existing condition such as diabetes. Virtual selves may be incorporated in existing virtual reality exposure treatments for phobias or social anxiety reduction. Athletes were previously limited to watching videotapes of others' performances of a technique or of the self demonstrating a potentially imperfect technique, but virtual selves could show the self performing a flawless volleyball set, a perfect roller derby hit, or the ideal baseball swing. These representations may also be effective in bolstering self-efficacy and perhaps performance in other domains, such as work tasks or social interactions. For example, people could learn from their virtual selves how to negotiate, speak assertively, or demonstrate leadership skills. Additionally, persuasive virtual selves may be used to enhance prosocial behaviors, such as recycling, conservation, donating blood, or volunteering.

Although these suggestions all describe situations in which virtual selves may be used to promote positive behaviors, there are of course situations in which these could be used to manipulate users. The incorporation of virtual selves in persuasive messages calls for investigation of this concept from an ethical perspective. Previous research has shown that incorporating elements of the self can lead to subconscious persuasion. If an agent imperceptibly mimics a person's nonverbal gestures, people are more persuaded by the agent (Bailenson & Yee, 2005). Blending a photograph of the self with that of a political candidate makes undecided voters prefer that candidate (Bailenson et al., 2006). Participants who saw themselves associated with a fictitious soft drink brand in an online advertisement showed preference for that brand later on (Ahn & Bailenson, 2009). Although the studies reported here sought to have a positive impact on health behaviors, the same techniques may be used for ill gain. For example, companies could use virtual selves to sell harmful products, from junk food to cigarettes to diet pills, by creating a subconscious brand preference through self-association. Given the prevalence of users portraying their photographs on public social networking sites, and many of these sites (e.g., Facebook) retaining the right to redistribute and use these photographs, it may be only a matter of time before images of the self become a new currency among advertisers, political campaigns, and other organizations. Thus, further examination of the social, psychological, and even legal ramifications of the virtual self is necessary.

Collectively, these studies have provided a wealth of information on the utility of virtual selves as models for health behavior change. Within the framework of social cognitive theory, virtual selves can be used to promote identification, demonstrate vicarious reinforcement, and enhance feelings of self-efficacy regarding health behaviors. Given the amount of time people spend engaging with new media via computers, gaming systems, and mobile devices, these models have the potential to become powerful motivators in day-to-day health efforts. As we observe our virtual selves evolve as they adopt and maintain healthful behaviors, we, too, can become healthy individuals.

NOTES

[1] Some of the pretests outlined here have been previously published in journals. Pretests 1, 2, and 3 appeared in *Media Psychology* (Fox & Bailenson, 2009). Pretest 5 appeared in *PRESENCE: Teleoperators & Virtual Environments* (Fox et al., 2009).

[2] 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.

[3] 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.

[4] This finding is also significant using the data without the wisterization.

[5] All tests involving the presence variable were repeated using the subscales of environmental, social, and self-presence. However, no distinct findings were found using the subscales, and so analyses are reported for the summary variable.

[6] A percent change variable was also calculated by subtracting the participants' Time 2 estimated pushups from the Time 3 estimated pushups and dividing by the Time 2 estimated pushups. Using this measure, women in the VE condition ($M = .29$, $SD = .55$) reported a greater increase in the number of pushups they believed they could do than women in the MP condition ($M = .00$, $SD = .22$), $F(1, 38) = 6.30$, $p < .05$, partial $\eta^2 = .14$. There were no differences between high self-efficacy ($M = .05$, $SD = .13$) and low self-

efficacy (*M* = .10, *SD* = .46) women, $F(1, 38) = 2.42$, $p > .05$, partial $\eta^2 = .06$, nor was the interaction effect significant, $F(1, 38) = 2.40$, $p > .05$, partial $\eta^2 = .06$. There were no significant effects for men. There were no differences between men who received the VE (*M* = .15, *SD* = .31) or MP (*M* = .08, *SD* = .28) treatment on estimated pushups, $F(1, 25) = .09$, $p > .05$, partial $\eta^2 = .00$. There were no differences between high self-efficacy (*M* = .23, *SD* = .36) and low self-efficacy (*M* = .05, *SD* = .24) men, $F(1, 25) = 2.38$, $p > .05$, partial $\eta^2 = .09$, nor was the interaction effect significant, $F(1, 25) = .47$, $p > .05$, partial $\eta^2 = .02$.

[7] A percent change was also calculated by subtracting the participants' Time 3 pushups from the Time 1 pushups and dividing by the Time 1 pushups. There were no significant effects for women. There were no differences between women who received the VE (*M* = .35, *SD* = .79) or MP (*M* = .61, *SD* = 1.34) treatment percent change of pushups, $F(1, 38) = .06$, $p > .05$, partial $\eta^2 = .00$. There were no differences between high self-efficacy (*M* = .20, *SD* = .33) and low self-efficacy (*M* = .71, *SD* = 1.44) women, $F(1, 38) = .86$, $p > .05$, partial $\eta^2 = .02$, nor was the interaction effect significant, $F(1, 25) = .67$, $p > .05$, partial $\eta^2 = .02$. No significant effects were found for men, either. There were no differences between men who received the VE (*M* = .18, *SD* = .28) or MP (*M* = .18, *SD* = .31) treatment percent change of pushups, $F(1, 25) = .37$, $p > .05$, partial $\eta^2 = .02$. There were no differences between high self-efficacy (*M* = .07, *SD* = .30) and low self-efficacy (*M* = .23, *SD* = .27) men, $F(1, 38) = 3.07$, $p = .09$, partial $\eta^2 = .11$, nor was the interaction effect significant, $F(1, 25) = 3.14$, $p = .09$, partial $\eta^2 = .11$.

APPENDIX A: STUDY 1 SURVEY ITEMS

Avatar Resemblance

(1 = *Definitely did not look like me at all*; 2 = *Mostly did not look like me*; 3 = *Looked somewhat like me*; 4 = *Mostly looked like me*; 5 = *Definitely looked a lot like me*)

1. To what degree did the avatar you saw resemble you in the face?

2. To what degree did the avatar you saw resemble you in the body (before any changes)?

3. Overall, how much do you feel the avatar resembled you?

Avatar Race

(African/African-American/Black; Asian/Asian-American; Caucasian/European-American/White; Latino/a; Other)

4. What race did the avatar appear to be?

Identification

(1 = *Strongly disagree*; 2 = *Somewhat disagree*; 3 = *Neither disagree nor agree*; 4 = *Somewhat agree*; 5 = *Strongly agree*)

5. While observing the virtual scene, I felt as if I was part of the action.

6. While observing the virtual scene, I forgot myself and was completely absorbed.

7. I think I have a good understanding of my avatar.

8. While observing the virtual scene, I could feel the experiences my avatar portrayed.

9. While observing the virtual scene, I wanted my avatar to succeed in achieving his or her goals by exercising and losing weight.

10. While observing the virtual scene, I felt I could really get inside my avatar.

11. At key moments, I felt I knew exactly what my avatar was going through.

12. While observing the virtual scene, I did not want my avatar to fail and gain weight.

Presence

(1 = *Not at all*; 2 = *Slightly*; 3 = *Moderately*; 4 = *Very much*; 5 = *Extremely*)

13. To what extent do you feel the avatar you saw is an extension of yourself?

14. To what extent do you feel that if something happens to the avatar you saw, it feels like it is happening to you?

15. To what extent do you feel you embodied the avatar you saw?

16. To what degree did you identify with the avatar you saw?

17. To what extent did you feel you were in the same room as the avatar you saw?

18. To what extent did the avatar you saw seem real?

19. To what extent were you involved in the environment?

20. To what extent did you feel like you were inside the environment?

21. To what extent did you feel surrounded by the environment?

22. To what extent did it feel like you visited another place?

23. How much did the environment seem like the real world?

Specific Self-Efficacy

(1 = *Strongly disagree*; 2 = *Somewhat disagree*; 3 = *Neither disagree nor agree*; 4 = *Somewhat agree*; 5 = *Strongly agree*)

24. I could perform the exercise I saw in the real world at a steady rate for 30 minutes.

25. I would have no problems performing the exercise I saw at a steady rate for 30 minutes.

26. Given the opportunity, nothing would stop me from performing the exercise I saw at a steady rate for 30 minutes.

27. I would be successful performing the exercise I saw at a steady rate for 30 minutes.

28. There are too many obstacles for me to perform the exercise I saw at a steady rate for 30 minutes.

29. I would fail at performing the exercise I saw at a steady rate for 30 minutes.

30. The exercise I saw is too challenging to perform at a steady rate for 30 minutes.

General Self-Efficacy

Please respond to the following items. Consider how you are feeling right now, at this moment, and whether or not you could do these things continuously for the next three months. I feel I could do the following activities for the next three months: (1 = *Very confident I could not do it*; 2 = *Mostly confident that I could not do it*; 3 = *Not sure if I could or could not do it*; 4 = *Mostly confident that I could do it*; 5 = *Very confident that I could do it*).

31. Stick to my exercise program even after a long, tiring day at work or school.

32. Set aside time for physical activity such as walking, jogging, swimming, biking, or other continuous forms of exercise for at least 30 minutes 3 times a week.

33. Stick to my exercise program even when I have excessive demands at work or school.

34. Spend less time reading, studying, or working on the computer in order to exercise more.

35. Get up earlier, give up naps, stay up later, or make other alterations to my sleep schedule to make time to exercise.

36. Make time, even on weekends, to exercise.

37. Stick to my exercise program even when friends and family are demanding more time from me.

38. Stick to my exercise program even when I have a lot of household chores and errands to attend to.

39. Exercise even when I am feeling sad or depressed.

40. Stick to my exercise program even when social obligations are very time consuming.

41. Stick to my exercise program when undergoing a stressful event (e.g., finals, moving, a death in the family).

42. Stick to an exercise program even when the results I want are taking a long time to achieve.

43. Stick to an exercise program even when I'm not seeing the results I want.

44. Exercise even though it is physically challenging.

45. Stick with an exercise program even if I don't reach a specific goal I have.

Racism

(1 = *Strongly disagree*; 2 = *Somewhat disagree*; 3 = *Neither disagree nor agree*; 4 = *Somewhat agree*; 5 = *Strongly agree*)

46. It is easy to understand the anger of minorities in America.

47. The streets are not safe these days without police or other surveillance.

48. Minorities are getting too demanding in their push for equal rights.

49. Over the past few years, minorities have gotten more economically than they deserve.

50. Over the past few years, the government and media have shown more respect to minorities than they deserve.

51. Minorities are gaining more advantage than they deserve through affirmative action in schools and workplaces.

APPENDIX B: STUDY 1 CONDITION x SEX FACTORIAL ANOVA RESULTS

DV	Effect	F-test Results	Conclusion
Identification	Condition	$F(2, 69) = .55$, $p > .05$, partial $\eta^2 = .02$	No effect
	Sex	$F(2, 69) = .02$, $p > .05$, partial $\eta^2 = .00$	No effect
	Interaction	$F(2, 69) = 2.31$, $p = .11$, partial $\eta^2 = .06$	No effect
Specific Self-Efficacy	Condition	$F(2, 69) = .70$, $p > .05$, partial $\eta^2 = .02$	No effect
	Sex	$F(2, 69) = .59$, $p > .05$, partial $\eta^2 = .01$	No effect
	Interaction	$F(2, 69) = 2.71$, $p = .07$, partial $\eta^2 = .07$	Borderline effect
Exercise Repetitions	Condition	$F(2, 69) = .83$, $p > .05$, partial $\eta^2 = .02$	No effect
	Sex	$F(2, 69) = 1.36$, $p > .05$, partial $\eta^2 = .02$	No effect
	Interaction	$F(2, 69) = .65$, $p > .05$, partial $\eta^2 = .02$	No effect
Presence	Condition	$F(2, 69) = .03$, $p > .05$, partial $\eta^2 = .00$	No effect
	Sex	$F(2, 69) = 2.88$, $p = .09$, partial $\eta^2 = .04$	No effect
	Interaction	$F(2, 69) = 1.34$, $p > .05$, partial $\eta^2 = .04$	No effect
General Self-Efficacy	Condition	$F(2, 69) = 1.14$, $p > .05$, partial $\eta^2 = .03$	No effect
	Sex	$F(2, 69) = 8.29$, $p = .005$, partial $\eta^2 = .11$	Men > Women
	Interaction	$F(2, 69) = .26$, $p > .05$, partial $\eta^2 = .01$	No effect

APPENDIX C: STUDY 1 SELF VS. OTHER (SIMILAR & DISSIMILAR) *t*-TEST RESULTS

DV	Self		Other		*t*-Test	Conclusion
	M	*SD*	*M*	*SD*		
Resemblance	2.76	.66	2.09	.70	$t(72) = 3.96$, $p < .0005$, Cohen's $d = .99$	Self > Other
Identification	2.89	.83	2.84	.71	$t(72) = .27$, $p > .05$, Cohen's $d = .07$	No effect
Specific SE	3.76	1.08	3.79	.96	$t(72) = .09$, $p > .05$, Cohen's $d = .03$	No effect
Exercise Repetitions	41.54	40.97	39.83	41.55	$t(72) = .17$, $p > .05$, Cohen's $d = .04$	No effect
Presence	2.87	.72	2.92	.64	$t(72) = .29$, $p > .05$, Cohen's $d = .07$	No effect
General SE	3.81	.97	3.49	.88	$t(72) = 1.44$, $p > .05$, Cohen's $d = .35$	No effect

APPENDIX D: STUDY 1 SELF & SIMILAR VS. DISSIMILAR *t*-TEST RESULTS

DV	Self/Similar		Dissimilar		*t*-Test	Conclusion
	M	*SD*	*M*	*SD*		
Resemblance	2.65	.65	1.72	.58	$t(73) = 6.06$, $p < .0005$, Cohen's $d = 1.51$	Self/Similar > Dissimilar
Identification	2.80	.76	2.92	.74	$t(73) = .62$, $p > .05$, Cohen's $d = .16$	No effect
Specific SE	3.86	1.00	3.63	.98	$t(73) = .95$, $p > .05$, Cohen's $d = .23$	No effect
Exercise Repetitions	44.44	41.89	32.28	38.03	$t(73) = 1.22$, $p > .05$, Cohen's $d = .30$	No effect
Presence	2.89	.67	2.91	.67	$t(73) = .13$, $p > .05$, Cohen's $d = .02$	No effect
General SE	3.67	1.00	3.46	.70	$t(73) = .91$, $p > .05$, Cohen's $d = .24$	No effect

APPENDIX E: STUDY 2 SURVEY ITEMS

Pretest

Time 1 Pushup Performance

1. Please indicate how many pushups you think you could do in one minute while maintaining good form. These are full form pushups from your toes, not your knees, where your back is flat and your butt is not arched in the air. In good form, your body goes all the way down until nearly touching the ground and is pushed all the way up until the arms are nearly straight. If you need to take a break, that's fine, but do not count any repetitions after sixty seconds.

How many pushups did you complete in one minute?

Time 1 Pushup Self-Efficacy

How confident are you that you could perform the following number of pushups in one minute while maintaining good form? (1 = *Definitely could not do it*; 2 = *Probably could not do it*; 3 = *Not sure*; 4 = *Probably could do it*; 5 = *Definitely could do it*)

2. 5 pushups in 1 minute

3. 10 pushups in 1 minute

4. 15 pushups in 1 minute

5. 20 pushups in 1 minute

6. 25 pushups in 1 minute

7. 30 pushups in 1 minute

8. 40 pushups in 1 minute

9. 50 pushups in 1 minute

10. 60 pushups in 1 minute

11. 70 pushups in 1 minute

12. 80 pushups in 1 minute

13. More than 80 pushups in 1 minute

Experimental Survey

These questions are about the images and human representation you saw in the first task.

Resemblance

(1 = *Definitely did not look like me at all*; 2 = *Mostly did not look like me*; 3 = *Looked somewhat like me*; 4 = *Mostly looked like me*; 5 = *Definitely looked a lot like me*)

1. To what degree do you feel the representation resembled you in the face?

2. To what degree do you feel the representation resembled you in the body?

3. Overall, how much do you feel the representation resembled you?

Identification

(1 = *Strongly disagree*; 2 = *Somewhat disagree*; 3 = *Neither disagree nor agree*; 4 = *Somewhat agree*; 5 = *Strongly agree*)

4. While observing the scene, I felt as if I was part of the action.

5. While observing the scene, I forgot myself and was completely absorbed.

6. I think I have a good understanding of my representation.

7. While observing the scene, I could feel the experiences my representation portrayed.

8. While observing the scene, I wanted my representation to succeed in achieving his or her goals by finishing the pushups in one minute.

9. While observing the scene, I felt I could really get inside my representation.

10. At key moments, I felt I knew exactly what my representation was going through.

11. While observing the scene, I did not want my representation to fail and not finish the set of pushups.

Presence

(1 = *Not at all*; 2 = *Slightly*; 3 = *Moderately*; 4 = *Very much*; 5 = *Extremely*)

12. To what extent to do you feel the representation is an extension of yourself?

13. To what extent do you feel that if something happens to the representation, it feels like it is happening to you?

14. To what extent do you feel you embodied the representation you saw?

15. To what degree did you identify with the representation?

16. To what extent did you feel you were in the same room with the representation?

17. To what extent did the representation seem real?

18. To what extent were you involved in the world you saw?

19. To what extent did you feel like you were inside the world you saw?

20. To what extent did you feel surrounded by the world you saw?

21. To what extent did it feel like you visited another place?

22. How much did the world you saw seem like the real world?

Specific Self-Efficacy

(1 = *Strongly disagree*; 2 = *Somewhat disagree*; 3 = *Neither disagree nor agree*; 4 = *Somewhat agree*; 5 = *Strongly agree*)

23. I could perform the exercise I saw in the real world at the pace I saw (that number of pushups in 1 minute).

24. I would have no problems performing pushups at the pace I saw.

25. Given the opportunity, nothing would stop me from performing pushups at the pace I saw.

26. I would be successful performing pushups at the pace I saw.

27. There are too many obstacles for me to perform pushups at the pace I saw.

28. I would fail at performing pushups at the pace I saw.

29. Pushups are too challenging to perform at the pace I saw.

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