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# PHYSIOLOGICAL RESPONSES TO VIRTUAL SELVES AND VIRTUAL OTHERS

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**Previous research indicates that photorealistic virtual representations (i.e., agents and avatars) of the self can influence attitude and behavior change. This study was designed to test participants' physiological reactions to exercising or still agents that resembled the self or a stranger. A within-subjects experiment tested participants' (N = 10) skin conductance in response to running and loitering virtual selves (created from participants' photographs) and virtual others. Participants entered a fully immersive virtual environment and observed the agents as their physiological response was measured. Arousal was greatest when exposed to a running virtual self or a loitering virtual other. The finding that the virtual self causes physiological arousal may explain why a running virtual self has been shown in previous research to increase exercise behavior after exposure. Implications for the development of Virtual Reality exercise treatments and other virtual therapies are discussed.**

***Keywords:*** **Avatars, Immersive Virtual Environments, Virtual Agents, Virtual Reality, Cybertherapy**

The use of virtual environments (VEs), including video games and virtual worlds, is becoming increasingly common for social interaction (Kaiser Family Foundation, 2010; Pew Research Center, 2010). VEs are also becoming an increasingly popular place for persuasive messages, from health campaigns to marketing efforts. Virtual representations (i.e., avatars and agents) are often implemented in these interactions, and thus it is important to determine how users respond to these representations (Blascovich, Loomis, Beall, Swinth, Hoyt, & Bailenson, 2002; Gaggioli, Mantovani, Castelnuovo, B. K. Wiederhold, & Riva, 2003) and what characteristics influence the utility of these representations (e.g., Nguyen, Merienne, & Martinez, 2009).

Virtual representations may attempt to persuade us through direct interaction, or they may be used as models to depict desirable behavior that observers may imitate based on several factors. Social cognitive theory argues that when models are similar to us, the process of *identification* occurs and we are more likely to imitate the behaviors models portray (Bandura, 1977, 2001). New technologies allow us to use photographs to build virtual humans that look remarkably like the self, thus creating highly similar models with which users can identify (Fox & Bailenson, 2010). Indeed, previous research has indicated that these photorealistic virtual selves are powerful persuasive tools (Fox, Bailenson, & Binney, 2009; Yee & Bailenson, 2007) causing people to prefer an advertising brand (Ahn & Bailenson, 2011) or leading children to create false memories (Segovia & Bailenson, 2009). Virtual selves have the potential to be powerful tools in virtual therapies. For example, socially anxious people could observe their virtual selves successfully engaging in social interaction, thus bolstering their self-efficacy. Users undergoing physical rehabilitation could see their virtual selves achieving both proximal and distal goals, providing motivation and encouragement to continue therapy (Fox & Bailenson, 2010).

Virtual selves have been tested in the exercise domain. In a previous study (Fox & Bailenson, 2009), participants were exposed to one of three virtual representations under the pretense that they were performing a memory task. Participants viewed a virtual representation of the self running (Running Self), a virtual self loitering (Loitering Self), or a virtual representation of another person running (Running Other) for approximately five minutes. The next day, participants' physical activity for the 24 hours following the experiment was tallied; participants who had seen the Running Self exercised significantly more (approximately one hour more) than those who had seen the Loitering Self or the Running Other. The reason for these findings, however, was unclear; thus, a follow up study was designed.

For this study, we wanted to address whether observing the self or other models, or running or loitering models, resulted in differing levels of physiological arousal. Physiological responses provide objective measurements that can determine the effects of virtual treatments on users (B. K. Wiederhold, Jang, Kim, & M. D. Wiederhold, 2002). Because the Running Self 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.

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## Method

### Apparatus

Participants were placed in an immersive virtual environment. They donned a head-mounted display (HMD) through which they were able to view each stimulus. Sensing equipment tracked users' head motion so that a realistic visual depiction of the environment could be updated constantly based on their movements.

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. 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 1 for the experimental apparatus setup.

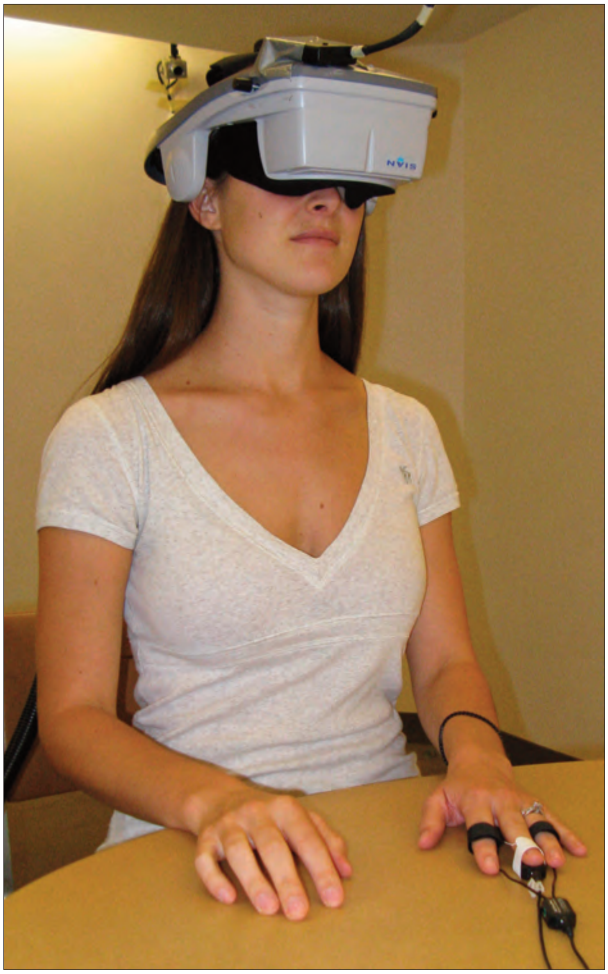

*Figure 1*. The experimental setup. The participant wears a head-mounted display (HMD) to view the stimulus while the sensors on her hand collect physiological data.

### Procedure

The sample ($N$ = 10) consisted of five men and five women ranging in age from 18-29 ($M$ = 22.22, $SD$ = 4.29) for which within-subjects comparisons were performed.

Participants were instructed that their task was to watch four sequences featuring different agents. They were also advised to limit their movements as much as possible (i.e., sit still) while observing the virtual stimuli to prevent unnecessary noise in the physiological output. Participants were seated at a table, connected to the physiological equipment, and fitted with an HMD. An empty virtual room was portrayed for 2 min as participants adjusted to the virtual world and baseline physiological data were gathered. Participants then observed all four stimuli; each stimulus lasted 2.5 min and was followed by a 1.5 min recovery period in the empty virtual room to allow participants' physiological response to normalize before proceeding to the next stimulus. The stimuli, which were randomized for each participant, included a Running Self, Loitering Self, Running Other, and Loitering Other. Figure 2 depicts a virtual representation running and loitering. In total, participants were immersed in the virtual environment for approximately 18 min.

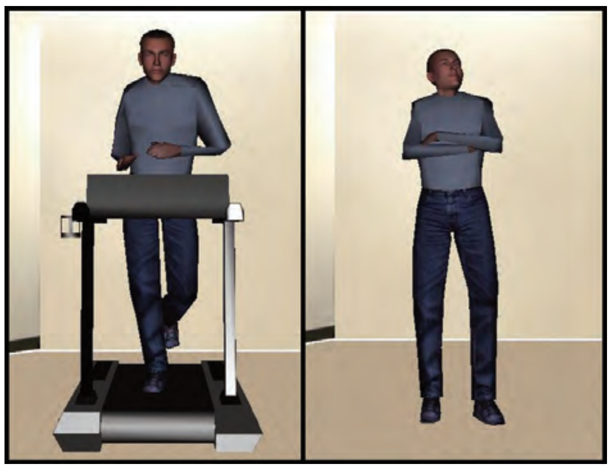

*Figure 2.* An example of a running and loitering virtual human.

### Physiological Data Processing

Skin conductance data is characterized by rapid spikes of varying amplitudes, referred to as skin conductance responses (SCRs) that indicate increases in arousal (Lang, 1994). From this data we extracted the mean amplitude of all SCRs for analysis.

## Results

Results indicated a significant difference in skin conductance across conditions, $F(3, 27) = 3.50$, $p < .05$, partial η2 = .28. See Table 1 for means and standard deviations. Planned contrasts in the form of paired t-tests revealed that participants demonstrated significantly greater skin conductance during the Running Self phase than the Loitering Self phase, $t(9) = 3.27$, $p < .01$, Cohen's $d$ = 1.31, and the difference from the Other Running phase bordered on significance, $t(9) = 1.91$, $p = .088$, Cohen's $d = 1.08$. Interestingly, there was no difference between Running Self and Loitering Other, $t(9) = .06$, $p > .05$, Cohen's $d = .04$. Additional analyses revealed that participants experienced greater skin conductance in the Other Loitering phase than during the Self Loitering, $t(9) = 2.40$, $p < .05$, Cohen's $d = 1.30$, or Other Running phases, $t(9) = 2.26$, $p = .05$, Cohen's $d = 1.09$.

Table 1
*Means and Standard Deviations for Conditions*

| | Running | Loitering |
|---|---|---|
| | *M* (*SD*) | *M* (*SD*) |
| Self | .29 (.49) | -.30 (.41) |
| Other | -.29 (.58) | .31 (.52) |

## Discussion

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 arousing because participants feel as if they are actually engaged in the exercise as they watch. Alternatively, the running self 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 memory of exerting oneself may cause the physical body to perspire without actually engaging in the behavior.

These results may offer some insight on the results of previous research (Fox & Bailenson, 2009) 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 exposure. Given the findings of this study, one possible explanation for the previous result is that participants experienced excitation transfer (Zillmann, 2003) and felt the need to engage in physical activity to manage their increased physiological arousal after seeing the virtual self running. It is also possible that participants' bodies were attempting to mimic the actions of the exercising virtual self, thus leading to greater arousal.

The finding that the loitering other 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 (Langer, Fiske, Taylor, & Chanowitz, 1976). Essentially, the experience mimicked that of 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. An important implication of this finding is that unfamiliar virtual humans have the potential to increase physiological arousal, which may affect or confound the desired impact of a virtual treatment or therapy.

This study has shown that virtual selves have the power to stoke a physiological response that may also serve as an impetus for physical behaviors and exercise applications. A woman who has trouble initiating a morning run might watch her virtual self jogging to get a kick start. Virtual selves also have a key advantage in that they can be manipulated to represent future states as well. If the woman is significantly overweight, she could see her future healthy self jogging and losing weight. Or, if she wants to run a marathon, she could watch her virtual self crossing a finish line. Additional research should investigate physiological responses to such virtual rewards to see how they can be incorporated in treatments.

These findings also lend insight on how Virtual Reality (VR) therapies in other realms may be developed for maximum effectiveness. An individual may be more psychologically and physiologically motivated to comply with a health treatment if the model is not a stranger, but rather the self capably performing these behaviors. Virtual selves, and the resultant identification, might lead to greater engagement, performance, and adherence to desired behaviors such as physical therapy or healthy dietary choices. Virtual selves also have the potential for implementation in other areas, such as cultivating a healthy body image (Guitérrez-Maldonado, Ferrer-García, Caqueo-Urízar, & Moreno, 2010) or treating anxiety (Pallavicini, Algeri, Repetto, Gorini, & Riva, 2009).

This study was limited as it sampled from a limited age range; further research should examine physiological responses of different groups. Although consistent with many physiological studies (Lang, 1994), the small sample size yielded power (.72) less than the desired level (.80). This study addressed one measure of physiological arousal; examining other physiological responses (e.g., breathing, heart rate, muscle responses) may substantiate these findings. Subjective data from participants may also offer additional insight into the variation in response to these virtual representations.

Future studies are needed to determine how and why virtual selves and others cause physiological arousal, as well as how participants manage that arousal. Virtual selves may demonstrate other healthy behaviors (such as making good dietary choices) or engage in risk behaviors such as smoking. Manipulating different aspects of virtual selves (e.g., realism, accuracy, or attractiveness, or showing rewards or punishments associated with certain actions) and measuring resulting levels of arousal may also lend insight on how these models may be maximally effective in influencing attitude and behavior change. Understanding physiological responses to virtual representations is crucial to understand many of the processes that occur during and after experiencing a virtual world.

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