Virtual and Live Social Facilitation While Exergaming: Competitiveness Moderates Exercise Intensity

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Grounded in social facilitation theory, this study compared the impact on exercise intensity of a virtual versus a live competitor, when riding a virtual reality-enhanced stationary bike (“cybercycle”). It was hypothesized that competitiveness would moderate effects. Twenty-three female college students were exposed to three conditions on a cybercycle: solo training, virtual competitor, and live competitor. After training without a competitor (solo condition for familiarization with equipment), participants competed against a virtual avatar or live rider (random order of presentation). A repeated-measures analysis revealed a significant condition (virtual/live) by competitiveness (high/low) interaction for exercise intensity (watts). More competitive participants exhibited significantly greater exercise intensity when competing against a live versus virtual competitor. The implication is that live competitors can have an added social facilitation effect and influence exercise intensity, although competitiveness moderates this effect.

Keywords: exercise behavior, virtual reality, health game, personality, presence

Concern over the epidemic of obesity in the United States continues to grow (26% in 2009; Centers for Disease Control and Prevention, 2010), with less than half of the population (48%) engaging in sufficient physical activity according to the Healthy People 2010 Objectives. Researchers have begun to explore novel alternatives to traditional physical activities in an effort to overcome barriers to physical activity like boredom, and entice sedentary persons “off the couch” by employing entertaining virtual reality and reinforcing interactive technologies in the development of exergames such as the Wii (Lieberman, 2009). Although there continues to be a need for research clarifying the degree of improvement in physical activity that can be obtained with exergames, there is a paucity of research on the application of traditional theories of physical activity to the human–computer interaction aspect of exergames. In this study we examine the applicability of social
facilitation (Strauss, 2002) for understanding the impact on exercise intensity when exergamers encounter a virtual versus a live competitor.

Social facilitation theory has evolved from early assertions that the mere presence or coaction of others could impact performance (Strauss, 2002). More recent conceptualizations explain variability in effect, both positive and negative, by accounting for situational factors (e.g., challenge versus threat; Blascovich, Mendes, Hunter, & Salomon, 1999; Rhea, Landers, Alvar, & Arent, 2003; Strauss, 2002). The present study draws from these theories to examine the impact on exercise intensity when a virtual competitor or avatar is presented on a computer screen, contrasted with a live competitor. Social facilitation situational factors (virtual vs. live competitor) were manipulated via a virtual reality–enhanced stationary bike, or “cybercycle,” while holding the competitive challenge constant (external motivation) with a relatively simple task of cycling on a stationary bike. Recent research found that one’s sense of “presence” (experiencing another as real) with a virtual versus a live competitor, is strongest for a live competitor (Ravaja et al., 2005). Thus, it was expected that a live rider would elicit a greater impact on exercise behavior. However, personality variables such as competitiveness can interact with or moderate exercise outcomes (Frederick-Recascino & Schuster-Smith, 2003; Sambolec, Kerr, & Messé, 2007). A recent pilot study in our laboratory had identified competitiveness as a moderator of exercise intensity when older adults were competing with a virtual cyclist (Anderson-Hanley, Snyder, Nimon, & Arciero, 2011). Therefore, competitiveness was assessed as a dispositional trait and it was expected that more competitive individuals would have a greater response to the live rider than less competitive individuals. The primary hypothesis for this study was that compared with less competitive individuals, more competitive individuals would expend greater exercise intensity with a live cyclist than a virtual cyclist.

**Methods**

**Participants**

Twenty-three college students from a small liberal arts college in northeast United States, aged between 17 and 22 ($M = 19.2$, $SD = 1.7$; 100% female; 18 Caucasians, four African-Americans, and one Hispanic), enrolled in and completed the study. We decided to enroll only women to control potential gender effects (Plante, Aldridge, Bogden, & Hanelin, 2003), and as a practicality given limited resources to employ a single (female) confederate cyclist (detailed below). Participants were recruited campus-wide for either research participation course credit (13%) or monetary reimbursement ($8; 87%). The study was approved by the college’s Human Subjects Review Committee and written informed consent was obtained from each participant.

**Measures**

**Competitiveness.** The Competitiveness Index (CI; Smither & Houston, 1992) has good reliability ($\alpha = .90$) and validity ($r = .61$ with an alternate competitiveness scale; Houston, McIntire, Kinnie, & Terry, 2002) and includes 20 true/false items relating to a participant’s interpersonal competitiveness in everyday contexts. Total scores range 0–20, with higher scores indicating greater competitiveness. The scores
ranged from 5 to 17; using a median split procedure, participants were classified as more \((M = 15.3; n = 11)\) or less \((M = 8.9; n = 12)\) competitive.

**Exercise Intensity.** Exercise intensity was captured by cybercycle sensors and recorded on the integrated computer system. The primary variable of interest in this study was exercise intensity (watts); other ride data captured and analyzed included heart rate (HR) and miles per hour (mph).

**Physical Activity.** Baseline daily physical activity (kcal) of each participant was estimated using the Aerobics Center Longitudinal Study Physical Activity Questionnaire (ACLS-PAQ; Kohl, Blair, Paffenbarger, Macera, & Kronenfeld, 1988). Prior research has demonstrated reasonable validity \((r = .40-.61)\) of self-report on the ACLS-PAQ compared with actual measured physical activity even up to 10 years later (Bowles, FitzGerald, Morrow, Jackson, & Blair, 2004). Metabolic equivalents were used to compute energy expended based on reported frequency, duration, and intensity of physical activities over the past 3 months. This measure categorizes 15 different forms of physical activity (e.g., walking, jogging).

**Procedure**

Participation occurred during two 30-min testing sessions on separate days (typically a 1-week interval) to minimize fatigue in subsequent conditions and to allow for discrete implementation of the confederate rider for conditions described below. In the first session, after completing measures described above, participant were instructed in the use of a recumbent stationary bike equipped with a computer display we refer to as a “cybercycle” (Expresso S3R). A 1-mile virtual reality “speedway” course was used in all conditions. Participants engaged in a warm-up ride to familiarize them with the equipment, in which they were instructed to strive for their best time; no other riders were present (“solo” condition).

Following the training ride and a 5-min rest period, participants were exposed to one of the two experimental social facilitation conditions (random order of presentation of either the virtual or live competitor). During the second session they again had a warm-up control ride and a 5-min rest period, and then completed the remaining social facilitation condition. In the virtual condition, participants were instructed to compete with the avatar that appeared on their computer screen. The cover story stated that the avatar was computer generated. Participants were unaware that the avatar was a confederate riding an interconnected cybercycle in a nearby room. The confederate was a strong athlete who could adjust her pace to match the participant’s and thus remains visible on the screen as a coacting social presence with the participant. As the finish approached, she would edge just in front of the participant to keep the relative pressure of the competition equivalent for each participant. In the live rider condition, participants were introduced to the confederate as if she was another participant in the study. They were positioned on interconnected cybercycles and were instructed to compete with each other by watching their avatars on-screen. As above, the confederate adjusted her ride speed to match the participant’s pace, and then edged ahead as the finish line approached.

**Data Analysis**

Using SPSS (v. 17) to evaluate the equivalence of the high- and low-competitiveness groups, independent samples \(t\) tests on baseline measures. A \(2 \times 2\) (high-/low-...
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Results

Baseline physical activity levels, and training HR and miles per hour of high and low competitiveness were comparable ($p = .19$, .64, and .06, respectively). However, baseline exercise intensity (watts) during training differed between the two groups and was entered as a covariate in the main analysis (high CI: $M = 106$; low CI: $M = 89$; $p = .05$). The primary analysis revealed a significant (group × condition) interaction. Competitiveness moderated exercise intensity, such that highly competitive riders rode more intensely in the presence of a live versus a virtual competitor, whereas less competitive riders did not exert additional intensity (Figure 1; $F[1,20]$ = 4.82, $p = .04$, controlling for solo training ride.)
Discussion

In this study we compared the impact of a virtual versus a live competitor on the exercise intensity of 23 college women riding a cybercycle (a virtual reality–enhanced stationary bike). Consistent with theoretical conceptualizations of social facilitation (Strauss, 2002), we found that more competitive riders exerted significantly greater cycling intensity (watts) than less competitive individuals when exposed to a live versus a virtual competitor.

Novel virtual reality–enhanced exercise, or exergaming, is being increasingly explored for its ability to encourage involvement in exercise, by addressing barriers to traditional exercise such as lack of enjoyment through involving virtual environments and compelling interactive gaming features (Lieberman, 2009; Plante, Aldridge, Bogden & Hanelin, 2003). This study examined the combined impact on measured exercise intensity of various factors within the virtual environment (such as the presence of a competitive avatar) and within the person (such as competitiveness). Our findings support social facilitation theories that suggest that exercise behavior can be impacted by the presence of others either as audience or competitors (Strauss, 2002), and supports prior research on the moderating role of individual competitiveness (Sambolec, Kerr, & Messé, 2007; Anderson-Hanley et al., 2011). Using a similar cybercycling intervention, Mestre and colleagues (2011) recently reported decreased perceived exertion and increased enjoyment when a virtual coach/pacer was present while cybercycling compared with traditional exercise. Our findings also fit with research showing one’s sense of “presence” (experiencing another as real) with a virtual versus a live competitor, is strongest for a live competitor (Ravaja et al., 2005). These findings also fit with results of a recent study that examined the Köhler motivation gain effect (Kerr, Messé, Seok, Sambolec, Lount, & Park, 2007) resulting from a virtually presented partner. Using an isometric plank exergame, it was found that participants performed significantly better than in a solo control condition, in all variants with a superior virtual partner (i.e., whether coacting, additive, or conjunctive; Feltz, Kerr, & Irwin, 2011). This suggests that working out with a superior virtual partner can be effective for enhancing exercise performance. Future research could examine the role of the Köhler effect by manipulating the confederate to be a known superior competitor over repeated trials, perhaps while also manipulating social facilitation by controlling an avatar’s presence on the screen or “behind the scenes.”

Overall, the findings of the study herein are consistent with previous literature and highlight that there is an effect of social facilitation and gains from the presence of a competitor when completing an exergaming task. Furthermore, participants found to be highly competitive exerted the greatest intensity in their workout in the presence of a live competitor, compared with a virtual competitor. These interesting behavioral variations in exercise response may be interpreted in light of research on video games, which has found that a greater level of threat is felt when competing against a live competitor compared with a virtual competitor.
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(Ravaja et al., 2005). When taking our results into consideration, it can be speculated that a more competitive personality could affect how an individual perceives and copes with threat, thus influencing how they react to such threat in a competitive exercise environment (Blascovich, Mendes, Hunter & Salomon, 1999). Whereas highly competitive individuals may excel in such situations, the performance of individuals with lower levels of competitiveness may be hindered.

The major practical implication of the current research is that personality should be taken into account when considering exercise interventions. In the competitive coacting exergame scenario herein, the nature of the competitor (virtual versus live) had different effects depending on the competitiveness of the exerciser. Compared with less competitive individuals, more competitive individuals benefitted the most from a live competitor. This finding suggests that whereas all individuals may benefit from the opportunity to perform an exergaming task, attention should be paid to how personality might influence one’s overall experience, especially if a live competitor is to be introduced. Given that part of the motivation behind exergaming is to make exercising more enjoyable and thus increase adherence, it is important to be aware that personality may subtly affect the apparent effectiveness of virtual reality–enhanced exercise paradigms. Future research on virtual reality–enhanced exercise may benefit from measuring personality tendencies such as competitiveness, to examine potential moderating effect, otherwise real effects could be obscured or muted, as would have been the case here had more and less competitive individuals been combined as a single sample.

One important limitation of the current research is the nature of the sample, which raises questions about the generalizability of the findings. Data are representative of only female college students of limited ethnic variability. Previous research has suggested that males and females respond differently when completing an exergaming task (Plante, Aldridge, Bogden, & Hanelin, 2003). It would be interesting to explore potential gender differences in response to a virtual versus live competitor, as well as perceived challenge or threat. Future research could evaluate the influence of other personality factors on exercise performance. Previous research has found that personality traits, are important sources of performance motivation (Frederick-Recascino, & Schuster-Smith, 2003; Sambolec, Kerr, & Messé, 2007). Efforts to measure intrinsic and extrinsic motivation could be examined as they apply to potential habitual use of virtual reality–enhanced exercise because the motivations behind engaging in an exercise activity can influence behavior (Sebire, Standage, & Vansteenkiste, 2011). Research has suggested that the perceived fitness level of a competitor, such as whether they are perceived as being highly fit or less fit, influences behavior (Plante et al., 2010). It would be interesting to alter the appearance of the virtual rider, as well as the live confederate rider and observe any additional effect.

In summary, the current research supports previous findings that social facilitation and personality tendencies can have a significant influence on exercise behavior. Virtual and live competitors were found to elicit different changes in exercise intensity, depending on the competitiveness of the exerciser. More research is needed to clarify the effects on exercise behaviors of social facilitation and personality factors in the evolving realm of exergaming.
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References


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