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# Short-Term Psychological Effects of Interactive Video Game Technology Exercise on Mood and Attention

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## ABSTRACT

Recent interest in interactive video game technology (IVGT) has spurred the notion that exercise from this technology may have meaningful physiological and psychological benefits for children and adolescents. The purpose of this study was to examine the short-term psychological effects of interactive video game exercise in young adults and whether IVGT participation was capable of improving mood as has been shown for traditional forms of exercise. In addition, we were interested in comparing both actual physical exercise output and perceived exertion of that output across the exercise conditions. One-hundred and sixty-eight college students were assigned to one of three 30-minute conditions: (1) interactive video game cycle ergometer exercise, (2) regular cycle ergometer exercise, or (3) a video game-only control condition. Positive and negative mood (PANAS; Watson, Clark, & Tellegen, 1988) was assessed before and twice-after experimental conditions, and measures of actual and perceived physical exertion were collected at five-minute intervals across exercise conditions. Participants in the video-game control had higher post-activity negative affect immediately and 10-minutes post activity than either exercise group. In addition, exercise condition participants had higher positive mood at 10-minutes post activity compared to the video game control participants. Results do not support IVGT mood benefits over other forms of exercise, but do support immediate affective benefits of exercise compared to sedentary activity. It is concluded that while there is potential for interactive video-game based applications to elicit affective benefits, there is a need to examine circumstances under which these benefits are most likely to occur.

## Keywords

Interactive video game technology, Mood, Exercise, Youth

A variety of research has shown that exercise enhances both physical and mental health (e.g., Berger, Pargman, & Weinberg, 2002; Carron, Hausenblas, & Estabrooks, 2003). The benefits from exercise include decreased risk for cardiovascular disease, osteoporosis, hypertension, certain cancers, poor cholesterol profiles, diabetes, and obesity (USDHHS, 1999). In addition to health benefits, exercise has shown to reduce risks of psychological problems like anxiety and depression (e.g. Carron, Hausenblaus, & Estabrooks, 2003; Schaie, Leventhal, & Willis, 2002) and enhance positive effects on psychological well-being and affective states such as mood improvement (Berger, Pargman, & Weinberg, 2002; Plante, Coscarelli, & Ford, 2001). Hansen, Stevens, and Coast (2001) showed increases in positive mood with as little as 10 minutes of moderate-intensity exercise, indicating even short bouts of exercise can produce positive psychological benefits. Furthermore, exercise has been shown to improve mood, regardless of other daily events (Giacobbi, Hausenblaus, & Frye, 2005) and has been reported as a successful method to self-regulate one's mood compared to other behavioral methods (Thayer, Newman, & McClain, 1994). Several explanations exist to explain how exercise enhances well-being and mood, however, no one explanation has support as a primary mechanism producing these positive changes (Weinberg & Gould, 2007). In addition, there is still lack of agreement as to whether exercise benefits occur directly from exercise, social or environmental factors in the setting, or are due to increased perceptions of benefits (Plante, 1999). It has recently been found that exercise in visually stimulating environments results in greater improvement in self-efficacy and mood than less-stimulating environments (McAuley, Talbot, & Martinez, 1999; Plante, Coscarelli, & Ford, 2001; Turner, Rejeski, & Brawley, 1997). The implications are that mood and self-efficacy improvements derived from exercise can be manipulated and that mood changes may be related to the interactive social and environmental experience, rather than to exercise itself.

Although exercise provides clear psychological and physical benefits, many Americans continue to be inactive, increasing lifestyle-related, chronic illnesses (USDHHS, 2000). A negative relationship has been reported between an individual's perception of exercise barriers and that their actual involvement in physical activity (Sallis, Hovell, Hofstetter, & Barrington, 1992). When citing barriers to exercise, lack of time, lack of energy, and lack of motivation are usually cited as primary reasons for inactivity (Canadian Fitness and Lifestyle Research Institute, 1996) and other research has indicated that, rather than environmental factors, virtually all exercise barriers are intrinsic and can be changed (Nahas, Goldfine, & Collins, 2003)

In adolescents, physical activity barriers involve factors such as lack of parental support, previous inactivity, siblings' nonparticipation in physical activity and being female (Sallis, Prochaska, & Taylor, 2000). Recent trends indicate children's lack of activity has been especially problematic. Children in the United States live in a society that has dramatically changed in the three decades that the obesity epidemic has developed. National overweight and obesity trends have been dramatic for youth and adolescents, with increases in prevalence of overweight in female children and adolescents from 13.8% in 1999-2000 to 16.0% in 2003-2004 and increases in prevalence of overweight in male children and adults from 14.0% to 18.2% for the same period (Ogden et al., 2006).

One cause of the recent increase in childhood obesity increase is lack of free-time physical activity and concurrent increases in "screen time", including television, computer use, and video game activity. As such, technology's impact on leisure activity, particularly among children and young adults, must be considered. For example, more than 150,000,000 Americans play video games more than once a week; 35,000,000 Sony Playstation 2 game consoles were sold in the United States in 2005, and in the same year, the video game industry was more than two billion dollars larger than the movie industry (Public Broadcasting System, 2006). Children's weight status has also been linked to higher weekly rates of video game use (Vandewater, Shim, & Caplovitz, 2004). Specifically, Vandewater et al (2004) found that in children under 12 years old, increased video game use was strongly related to weight status, whereas TV viewing was not, indicating video game use, more than TV use, is displacing children's physical activity. Recently, research examining adolescent males' perceived barriers to physical activity found that 15- and 16-year old boys reported a preference to engage in technology-related activities such as video games and computer activities over other self-selected, free-time activities. Specifically, when boys perceived time constraints in free time, they preferred to engage in computer-related activities over physical activity (Allison, Dwyer, Goldenberg, Fein, Yoshida, & Boulitier, 2005).

Not only do environments supportive of physical activity encourage exercise (Allison et al., 2005) but the environmental exercise context affects psychological benefits such as mood (Plante, Coscarelli, & Ford, 2001; Turner, Rejeski, & Brawley, 1997) and these environments may have implications for long-term enjoyment of, and adherence to exercise. In addition, recent suggestions for improving physical activity rates have noted that adherence might be improved by promoting greater focus on immediate gratification through exercise enjoyment (USDHHS, 1999). Sallis, Prochaska, Taylor, and Geraci (1999) examined potential determinants of physical activity in children (grades 4 to 12) and found that enjoyment of physical activity and physical education classes were among the strongest determinants. Emmons and Diener (1986) have also noted that the affect experienced during an activity is a good predictor of future activity involvement. Specifically, one is not likely to continue an activity that does not bring enjoyment or is not fun: a consideration factored into the moderate-intensity exercise prescription recommendation for most adults (National Institutes of Health Consensus Panel on Physical Activity and Cardiovascular Health, 1996). It should not be surprising then, that people who enjoy the process of physical activity are more likely to remain active.

An obvious dilemma then, in the effort to get more children and young adults physically active is that many sedentary activities are perceived as immediately-reinforcing and enjoyable, whereas many physical activities capable of improving health and fitness are perceived as less enjoyable and less immediately reinforcing. Yet, while the Surgeon General's Call to prevent childhood obesity (USDHHS, 2004) has cited increased television, computer, and video use as culprits for the obesity increase, a concurrent paradoxical development in the video game industry has been the surging popularity of interactive video game technology (IVGT). Concurrently, there has also been interest in whether new technology like virtual reality, can enhance certain psychological benefits associated with exercise (Plante et al., 2003a; Plante et al., 2003b).

Plante and colleagues (2003a) assessed stress management benefits of virtual reality (VR) paired with exercise in a lab setting by comparing 20-minute aerobic conditions of treadmill walking using virtual reality technology to a treadmill-walking control, walking outside, and virtual-reality control condition. Results indicated increased energy levels from actual exercise over virtual reality exercise. Males increased their mood from the combined exercise-VR condition, however, overall, the combined exercise-VR condition did not result in significant, positive mood changes compared to other exercise conditions. Plante and colleagues (2003b) also examined if VR technology enhanced mood-benefits of aerobic exercise by comparing VR combined with cycle ergometer exercise to a VR-control and bicycling ergometer control condition. Results indicated that the combination of virtual reality technology and exercise could improve certain psychological benefits, in that subjects in exercise conditions had more energy and relaxation as well as less tension post-exercise compared to a VR-control group. In addition, the combined VR-exercise condition resulted in more actual exertion (RPMs) and was perceived as most enjoyable (Plante et al., 2003b).

Movement-based interactive video game technology has been marketed specifically to adolescents and young adults, and includes such popular applications as Dance Dance Revolution, Xavix, Eye-Toy, Nintendo Wii, and CatEye fitness equipment that can be interfaced with video game consoles and are widely available to the general population compared to virtual reality applications. The principle of interactive games is the notion of getting players to directly interface their physical or sport-based movements so they directly control or coincide with movement activity within the video game. These interactive applications can elicit physical activity levels in which as many as 300-500 calories per hour may be expended and which may provide an immediate enjoyment factor or motivational incentive some children and young adults need to create interest in physical activity (Yang, Vasil, & Graham, 2005).

An additional possible value of IVGT exercise, related to active engagement and learning, might be its role as a structured extracurricular activity (SEA; Gilman, Meyers, & Perez, 2004). Gilman et al (2004) indicate two forms of adolescent activities exist that correspond with engagement: solitary, non-structured, non-cooperative activities, often done without adult supervision, such as regular video games and television watching, and highly structured, interactive activities, under the supervision of others, namely structured extracurricular activities. Such examples that would relate to IVGT might include computer clubs, exploration within technology classes, and graphic design art clubs. Structured extracurricular activities have been shown to represent a strategy that may build resilience in young adults by supporting pro-social behaviors, engagement in school and related activities, better academic performance, and growth in subjective well-being (Larson, 2000; Mahoney, 2000). Unlike unstructured activities, SEAs are highly organized activities that emphasize a skill-building aspect, in which skills attained can be monitored and nurtured under the guidance of a non-parental adult (Csikzentmihalyi, 1990; Mahoney & Stattin, 2000). The combination of progressive skill attainment and adult supervision, combined with the fact that they are voluntary and intrinsically motivating, makes SEAs effective contributions to active student engagement (Larson, 2000). A potential benefit then, of supervised exercise using interactive video game exercise may be in transforming a less-structured free time activity (video games) into a more meaningful, structured extracurricular activity, capable of enhancing student engagement.

Currently, physical educators and fitness professionals have shown interest in the notion of meeting adolescents and young adults at their motivational "entry point" (Hayes & Silberman, 2007) and integrating interactive video game technology into their programs to motivate them to be more physically active (NASPE, 2004; Trout, 2006; Yang, Vasil, & Graham, 2005). Yet, while the popularity of this technology to provide physical activity motivation in children and young adults has been recognized, there is a lack of research examining the empirical effects of this technology on physical and affective outcomes. Recently, there has been investigation of virtual reality technology effects on psychological outcomes associated with exercise (Plante et al., 2003a; 2003b) however, to our knowledge, no studies have examined short-term psychological outcomes of interactive video game technologies designed and marketed to mass populations with home-version video game consoles in a controlled setting. Therefore, the purpose of this study was to examine the short-term psychological effects of interactive video game exercise in a controlled, laboratory setting.

## Method

### Participants

A sample of 168 university students (78 males, 90 females) participated in the study. The mean age of students was 21.51 years (SD =5.31) who were obtained by solicitation of volunteers through university wellness courses. All participants in the exercise conditions were asked to abstain from exercise on the day of their participation to assure that observable psychological changes could be attributed to the lab conditions and not outside exercise.

## Design

All participants were randomly assigned to one of three 30-minute conditions (56 participants per condition): (1) regular bicycle ergometer exercise at a moderate intensity (60-70% of individual maximum heart rate), (2) video game interactive bicycle ergometer exercise at a moderate intensity (60-70% of individual maximum heart rate), and (3) a 30-minute video game-only control condition in which participants played the same video game as the interactive condition, without exercise. Mood states (the Positive Affect Negative Affect Schedules) were measured immediately before, after and 10-minutes each session, in each condition. Concentration was measured using a concentration grid exercise (Harris & Harris, 1984) activity immediately before and after each session.

## Measures

*Positive Affect and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988).*

The PANAS is a brief, 20-item self-report adjective list containing 10 positive mood adjectives and 10 negative mood adjectives. Sample positive mood adjectives include interested, excited, enthusiastic, and inspired. Sample negative mood adjectives include distressed, upset, hostile, and ashamed. Each adjective is scored on a five-point scale (from not-at-all to extremely) reflecting the degree to which the respondent is experiencing a particular mood at that exact moment. Watson, Clark, and Tellegen (1988) have reported adequate reliability and validity for the PANAS and the scale has been used in previous studies examining mood state changes through exercise contexts (Russell & Cox, 2000). In this study, scores on the PANAS ranged from 10 to 47 with positive affect (PA) means ranging from 29.82 (SD=7.1) pre-condition, to 29.34 (SD=8.1) immediately post-session and 25.86 (SD=9.05) at ten minutes after post-session. Negative affect (NA) means ranged from 13.64 (SD=3.59) pre-session to 12.64 (SD=3.29) immediately post-session and 12.02 (SD=2.79) at ten minutes after post-session.

*Marlowe-Crowne Social Desirability Scale (MC-SDS; Crowne & Marlowe, 1960)*

This scale measures social desirability or defensiveness and consists of 33 true-or-false statements (Crowne & Marlowe, 1960). Sample items are, “I sometimes think when people have a misfortune they only got what they deserved”, and “I always try to practice what I preach.” Items are scored one point for each item endorsed in the direction of social desirability or defensiveness. The Marlowe Crowne SDS has demonstrated acceptable internal consistency and construct validity (Crowne & Marlowe, 1960; Strahan & Gerbasi, 1972). In this study, the mean SDS score was 17.01 (SD =5.31) with a range of 5 to 32.

*The Attentional Grid (Harris & Harris, 1984)*

Concentration was assessed using a 60-second concentration grid exercise adapted from Harris and Harris (1984). This exercise is a 10 by 10 cell grid with each cell containing a number ranging from 0 to 99, in random order. The purpose is to scan the grid and find as many consecutive numbers, starting with zero, within 60 seconds, with higher scores indicating a more efficient ability to quickly scan a stimulus field and pick out relevant information.

*Ratings of Perceived Exertion (RPE; Borg, 1982, 1985)*

Within the exercise conditions, the RPE scale was used to measure participants’ perceived level of exertion. General ratings of perceived exertion (RPE) were assessed using Borg’s (1985) Perceived Exertion Scale (PES), ranging from 6 (minimal) to 20 (maximal), which has been frequently used in exercise research and has demonstrated adequate reliability and validity (Borg, 1985). Previous research has shown test-retest reliability at .80 or above, and the scale has been repeatedly valid for measuring perceived work and effort in exercise settings (Borg, 1985). The perceived exertion chart was placed in front of and to the left of participants, who were asked to rate their exertion according to this scale. Starting at 5 minutes into the session, RPE scores were recorded every 5 minutes and ranged from 6 to 18 with means at the various measurement periods ranging from 10.28 to 12.61 (SDs ranging from 1.80 to 2.26).

**Procedure**

Participants were obtained from university wellness courses. An undergraduate research assistant then contacted participants to schedule an appointment for the session. After a time was scheduled, the assistant informed the participant of the location to meet, the proper attire, and reminded exercise condition participants to refrain from exercise on the day of the experiment. As much as possible, participants were tested in pairs within each condition. The rationale was that two interactive video game bicycles were used and could be played at the same time in a split-screen video game format, thus, attempts were made to create paired activity sessions across all three conditions.

Once in the laboratory, participants' consent was obtained and height and weight were obtained in order to calculate participants' Body Mass Index (BMI). Participants were then fitted with a heart rate monitor (*Polar Model S610*) so that both resting and session heart rate changes could be monitored. Next, participants were assessed on positive and negative affect (PANAS) and social desirability (MC-SDS), followed by self-reported video game frequency (ranging from 1-*never* to 6-*every day)* and self-reported video game experience (1-*no experience* to 5-*lots of experience).* Participants were then given an attentional grid exercise in which they had 60-seconds to find as many randomly arranged numbers as possible in the concentration grid. Participants were told, starting with the number 1, to find and mark cells in the grid in consecutive order and to reach as high a number as possible in 60-seconds. After completing the pre-session surveys (but prior to starting the activity) resting heart rates were obtained so individualized target heart rate ranges could be calculated for participants.

Participants were then assigned to one of three conditions. The first condition was the exercise-control condition. Participants were positioned on a CatEye Game Bike (GB300 Model) interactive bicycle ergometer, without the ergometer connected to the television monitor or video game console. Each participant in this condition exercised on the bike for 30 minutes and every 5 minutes, RPMs and heart rate were recorded, and participants were asked to rate their perceptions of exertion according the Borg RPE scale. During the exercise conditions, participants were told to keep their heart rates within their target intensity (60-70% target heart rate). For the 30-minute sessions, there were a total of six measurements at five-minute intervals. After the sessions were completed, participants were seated and completed a post-session PANAS and 60-second attentional grid. In the post-session concentration grid, numbers were rearranged to avoid pre-session carry over effects. Across all conditions, after 10 minutes of quiet rest, participants once again completed a second post-session PANAS.

Participants who were randomly selected to participate in the interactive video game exercise condition, experienced the same assessments (in the same order) as participants in condition one. In this condition, participants played a video game (Smuggler's Run, Sony Playstation, 2000) on a television monitor placed three feet directly in front of them through cycling exercise. After completing the pre-session assessments, participants were placed on adjacent bicycles. The bicycle ergometers contained movable handlebars controlling steering movements of video game vehicles. In addition, an electronic speed sensor in the bike controlled video game vehicle speed within the game such that faster bicycle RPMs resulted in faster video game vehicle speeds. Participants were instructed to go to the main menu, select the two player format, and select a game called "loot grab" which participants played in a split screen format. Participants then scrolled through a menu in which they chose their vehicle and their racing environment. The ergometers contained hand-held controls mounted on the handle bars in which participants made their game selections, however, once the game was launched, all further video game interactions were controlled directly by participants' steering and pedaling speeds through the exercise.

The third condition was a video-game control condition in which participants experienced the same pre- and post-session assessments, were fitted with a heart rate monitor, and played the same video game (*Smuggler's Run*) as the interactive condition, without exercise. In this condition, the research assistant monitored and recorded heart rate every 5 minutes during the 30-minute session. Following the 30-minute session, the participants were given the same post-session assessments, including the PANAS and concentration grid immediately after the session and an additional PANAS after 10-minutes of quiet rest in the laboratory. The purpose of this condition was to compare affective and concentration changes from playing the same video game without any actual physical exercise being performed.

## Results

### Descriptive Summary and Baseline Measures

One-hundred and sixty eight (N=168) participants were included in the data analysis (78 males and 90 females). Means and standard deviations for age, HR, BMI, video game experience, video game frequency, and social desirability are provided in Table 1 by condition and gender. Table 2 contains PANAS scores (PA, NA) before, after, and 10 minutes post-session by gender and condition. A 2 (gender) by 3 (condition) ANOVA was used to examine potential pre-experimental condition baseline differences in positive and negative affect to insure that groups were not significantly different regarding affective states prior to conditions. For positive affect (PA), no baseline differences were found between the three conditions ($p$=.64) or between the gender ($p$=.45). Likewise, no baseline differences were evident for negative affect (NA) between conditions ($p$=.37) or between gender ($p$=.66). Thus, results indicated no differences across gender or condition on pre-session PA or NA.

*Table 1.* Means and standard deviations for age, heart rate, body mass index, video game experience, video game frequency, and social desirability

| | Male | | | Female | | |
|---|---|---|---|---|---|---|
| | Exercise | IVGT | VG | Exercise | IVGT | VG |
| N | 28 | 18 | 32 | 28 | 38 | 24 |
| Age | | | | | | |
| M | 23.39 | 20.44 | 21.78 | 22.04 | 21.32 | 19.63 |
| SD | 8.36 | 2.89 | 6.17 | 3.70 | 4.92 | 1.06 |
| HR (Resting) | | | | | | |
| M | 81.54 | 84.28 | 79.88 | 83.79 | 86.74 | 82.50 |
| SD | 11.31 | 11.60 | 8.12 | 10.21 | 13.38 | 5.52 |
| BMI | | | | | | |
| M | 28.29 | 28.95 | 28.83 | 27.27 | 25.69 | 24.69 |
| SD | 4.43 | 6.80 | 5.92 | 6.12 | 4.61 | 5.06 |
| Game Freq. | | | | | | |
| M | 3.82 | 4.22 | 3.81 | 2.64 | 2.21 | 2.37 |
| SD | 1.42 | 1.26 | 1.26 | 1.42 | .93 | .71 |
| Game Exp. | | | | | | |
| M | 3.86 | 4.22 | 3.84 | 2.75 | 2.58 | 2.75 |
| SD | 1.18 | .81 | 1.02 | 1.21 | .95 | .68 |
| Social Desirability | | | | | | |
| M | 18.25 | 18.89 | 16.00 | 16.61 | 17.58 | 15.08 |
| SD | 5.56 | 4.25 | 3.87 | 4.65 | 6.64 | 5.27 |

* IVGT = Interactive video game technology condition; VG = video game control condition

*Table 2.* PANAS scores before, after, and 10 minutes post-session by gender and condition

| Male | | | Female | | |
|---|---|---|---|---|---|
| Exercise | IVGT | VG | Exercise | IVGT | VG |

| | | | | | | |
|---|---|---|---|---|---|---|
| Pre-Condition | | | | | | |
| N | 28 | 18 | 32 | 28 | 38 | 24 |
| PA | | | | | | |
| M | 28.71 | 31.72 | 30.53 | 31.04 | 29.42 | 27.96 |
| SD | 7.14 | 6.86 | 7.38 | 6.83 | 6.82 | 6.93 |
| NA | | | | | | |
| M | 12.46 | 14.06 | 14.88 | 12.86 | 13.29 | 14.50 |
| SD | 3.01 | 4.52 | 4.13 | 2.96 | 2.99 | 3.78 |
| Post-Condition | | | | | | |
| PA | | | | | | |
| M | 27.39 | 31.50 | 28.38 | 31.93 | 29.53 | 28.00 |
| SD | 7.97 | 7.78 | 7.48 | 8.14 | 7.93 | 9.15 |
| NA | | | | | | |
| M | 12.00 | 12.00 | 13.91 | 11.68 | 12.26 | 13.88 |
| SD | 2.67 | 2.59 | 4.04 | 2.20 | 3.59 | 3.30 |
| 2nd Post-Condition | | | | | | |
| PA | | | | | | |
| M | 26.57 | 28.72 | 24.03 | 30.21 | 24.76 | 22.00 |
| SD | 8.82 | 9.84 | 8.97 | 7.73 | 9.05 | 8.35 |
| NA | | | | | | |
| M | 11.32 | 11.17 | 14.28 | 10.75 | 11.32 | 13.04 |
| SD | 1.68 | 1.82 | 3.72 | 1.38 | 2.36 | 2.94 |

* IVGT = Interactive video game technology condition; VG = video game control condition

**BMI and Social Desirability**

Two separate 2 (gender) by 3 (condition) factorial ANOVAs were conducted with BMI and social desirability as the dependent variables. There was a significant main effect for gender ($F_{(1,162)}$ =10.59, $p$<.001), indicating that the males had higher BMI ($M$=28.69) compared to females ($M$=25.88). A significant experimental condition effect was found for social desirability as well ($F_{(2,162)}$ =3.65, $p$<.05). Tukey HSD post-hoc analysis found that interactive video game participants reported being more defensive ($M$=18.23) than participants in the video game control condition ($M$=15.54; $p$<.05).

**PANAS Mood Results**

A series of 2 (gender) by 3 (condition) between-subjects ANCOVAs were performed on positive and negative affect using pre-session PA and NA, video game experience and social desirability scores as covariates. This allowed for determination of whether pre-condition affect, video game experience, and social desirability impacted the post-session mood outcomes.

*PANAS Results -* While examining the post-experimental PA scores, pre-condition PA was significantly related to post-condition PA ($F_{(1,161)}$ =100.25, $p$<.001), but there was no significant gender effect or condition effect for post-condition PA. When examining the post-experimental negative affect, pre-condition NA was found to be significantly related to post-condition NA ($F_{(1,161)}$ =330.94, $p$<.001). In addition, there was a significant main effect for condition on post-session NA ($F_{(2,161)}$ =3.46, $p$<.05), revealing that video game control participants experienced more post-session NA (*M*=13.41) compared to the interactive exercise condition (M=11.83) or the exercise control condition (*M*=12.48).

*Video Game Experience Results -* While examining post-session positive affect using self-reported video game experience as a covariate, no significant effects were found (all P's >.05), indicating previous video game experience had no influence on post-session positive affect. For negative affect, ANCOVA results indicated that previous video game experience was not related to post-session NA (*ns*). However, a significant main effect for condition ($F_{(2,161)}$ =6.49, $p<.001$) confirmed that participants in the video game control condition had more post-session NA compared to the interactive exercise and exercise control conditions.

*Social Desirability Results -* Examining post-session PA across condition using social desirability as a covariate, results indicated social desirability was not related to post-condition PA ($p>.05$). There was no main effect for gender (p>.05), however, there was a main effect for condition ($F_{(2,161)}$ =5.80, $p<.001$), indicating more NA after the video game control condition (*M*=13.89) compared to the interactive exercise condition (*M*=12.18) or the exercise control condition (*M*=11.84), even after co-varying out the effect of social desirability.

*10-minute Post-Session PANAS Results -* In order to examine the temporal patterning of post-session positive and negative affect across conditions, two separate 2 (gender) by 3 (condition) ANCOVAs were performed on positive and negative affect scores at 10 minutes after the completion of the initial post-session PANAS was completed, using pre-session PA and pre-session NA, respectively, as covariates. While examining these second post-session PA scores, pre-session PA was related to PA at 10 minutes post-session ($F_{(1,161)}$ =106.77, $p<.001$), and there was a significant main effect for condition ($F_{(2,161)}$ =7.08, $p<.001$) indicating that both the exercise control condition (*M*=28.39) and the interactive exercise condition (*M*=26.04) maintained more PA than the video game condition (*M*=23.16) at 10 minutes post-activity.

For the 2 (gender) by 3 (condition) ANCOVA examining negative affect at 10 minutes post-session, using pre-session negative affect as a covariate, pre-session NA was significantly related to the second post-session NA ($F_{(1,161)}$ =39.19, $p<.001$) and there was a significant main effect for condition ($F_{(2,161)}$ =14.22, $p<.001$), indicating that the video game control participants maintained significantly higher negative affect 10 minutes after their session (*M*=13.31) compared to the exercise control (*M*=11.34) or interactive (*M*=11.23) condition.

## Concentration Grid Results

While examining the post-condition attention scores using participants' pre-condition attention scores as covariates, results indicated that pre-condition attention scores were related to participants' post-condition attention scores ($F_{(1,161)}$=44.73, $p<.001$). However, no significant gender or condition effects were found for post-condition attention scores (All *P'*s >.05) when pre-condition attention or video game experience were co-varied out of the analysis.

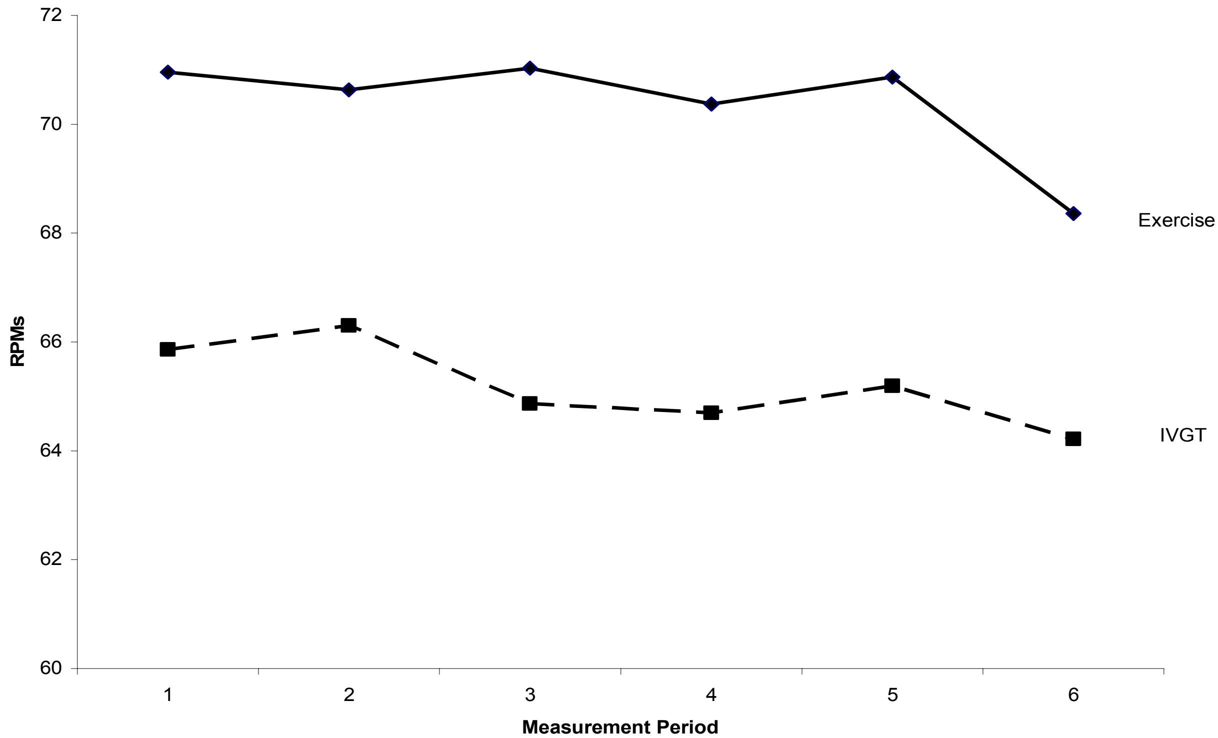
## Perceived Exertion Results

In order to compare possible perceptual differences in exertion during exercise across the two exercise conditions, a mixed model repeated measures ANOVA was performed comparing IVGT and exercise control participants on RPE, with measurement time as the within-subjects factor and exercise condition as the between-subjects factor. This analysis indicated no significant interactive effects of time and condition and a significant main effect for time ($F_{(1,110)}$ =95.55, p<.001). While the main effect for condition was not significant ($F_{(1,110)}$ =3.35, p=.07), results did display a trend toward significance with IVGT participants showing a trend toward higher RPE values at each measurement period.

## Actual Exertion Results

A mixed model, repeated measures ANOVA was also performed comparing IVGT with exercise control participants on actual RPMs, with measurement time as the within-subjects factor and exercise condition as the between-subjects factor. In this analysis, no significant time by condition interaction or main effect for time was found. However, results indicated a significant main effect for condition ($F_{(1,110)}$ =7.37, p<.05), indicating that for each measurement period, participants in the exercise control condition had greater actual exertion levels compared to IVGT participants (Figure 1).

**Figure 1 - Actual Exertion(RPMs) across Exercise Conditions**




## Discussion

The purpose of this study was to examine whether interactive video game-based exercise enhanced affective benefits of exercise in a controlled setting. A secondary purpose was to examine any potential differential concentration changes from interactive exercise compared to exercise or video-game controls. Recent work has noted potential benefits from regular engagement in this technology beyond entertainment, including improvement of rehabilitation performance in disabled populations (Harrison et al., 2002), military training (Hays & Vincenzi, 2000), phobia treatment (Weiderhold & Weiderhold, 2000), spatial abilities (de Lisi & Wolford, 2002), motor skills (Fery & Ponserre, 2001), visual selective attention (Green & Bavelier, 2003), and problem-solving capabilities (Ko, 2002), and knowledge acquisition and retention in military trainees (Ricci, Salas, & Cannon-Bowers, 1996). Such affective and concentration improvements resulting from interactive video game exercise could have beneficial implications in serving as a type of structured extracurricular activity and enhance student engagement.

Recently developed interactive, exercise-based video game applications (such as the one used in this study) are marketed to increase the enjoyment of the exercise experience by pairing the activity with an inherently enjoyable activity for many children and young adults: the video game experience. Research has also examined virtual reality technology for its potential to enhance various psychological benefits from aerobic exercise (Plante et al., 2003a; 2003b). Current study results provided only marginal support for the hypothesis that interactive video game-based exercise would provide more beneficial mood changes compared to exercise or video game control conditions. In addition, there was no support for the hypothesis that exercise within an interactive condition would result in enhanced concentration immediately after the activity compared to exercise or video game controls. Finally, the current results indicate the need to carefully examine the circumstances under which interactive video may provide advantages over more traditional exercise when considering psychological and physical benefits. Results from immediate post-session affect across conditions appear to reinforce the notion that exercise, in any capacity, produces significant mood benefits (e.g. Berger & Owen, 1998). More importantly, this study indicates the possibility of utilizing IVGT as an attraction to induce interest in exercise, thereby leading to the physical and mood benefits derived from the exercise itself.

Results from 10-minute post-session affect across conditions indicated that exercise-control and IVGT conditions exhibited more beneficial affect profiles compared to the video game condition. This supports that exercise itself dictated levels of PA and NA, not the presence of video games. However, because both the exercise control and IVGT condition produced relatively similar mood benefits, an argument may be made for the using IVGT exercise to augment traditional exercise equipment, especially when using them with children and young adults The use of video games for serious educational purposes is gaining attention from educators and educational theorists (Aldrich, 2005; Klopfer & Yoon, 2005; Squires & Jenkins, 2003). If anything, current results indicate that IVGT-interfaced exercise equipment could constitute an alternative teaching method producing equitable results. Virtual reality (VR)-based exercise has recently been compared VR- and exercise-control conditions on stress management effects (Plante et al. 2003a), and increased energy levels were more likely to occur with actual exercise than with virtual reality exercise. Specifically, Plante et al (2003a) concluded that virtual reality paired with actual exercise did not result in the most significant and positive changes in mood relative to other conditions. Other work with VR-based exercise (Plante et al. 2003b) has found that the enjoyment of virtual exercise provides additional psychological benefits, but that in general, exercise (with or without virtual reality) improved mood immediately following exercise. In this sense, results of the current study support previous work in this area comparing short-term psychological effects of virtual reality and exercise.

Contrary to expectations, the interactive video game exercise condition did not result in greater mood benefits or concentration improvements compared to other conditions. Several potential reasons may have accounted for this finding. First, while all conditions were equivalent in participants (n=58), the number of females and males differed across conditions. Previous research with virtual reality applications has found that females generally gained greater mood benefits from actual exercise, compared to virtual reality-combined exercise (Plante et al. 2003a) and that females are more tense compared to males when engaging in virtual reality exercise (Plante et al. 2003b). In the current design, there were more females in the interactive exercise condition (n= 18 males; 38 females), while more males were in the video game control condition (n =32 males; 24 females). This gender difference across conditions, combined with gender differences in video game experience (males' M =3.94; females' M =2.68) and video game frequency (males' M =3.91; females' M =2.39) may have accounted for the nonsignificant comparison of the IVGT condition compared to the other conditions. Second, several participants within the exercise conditions expressed that the ergometer seat was uncomfortable after completion of their 30-minute ride. Although speculative, it is likely that for at least some participants, if their reported discomfort with the ergometer seat was sufficient enough, the discomfort may have negatively influenced mood scores immediately following the session.

Results from perceived and actual exertion during the exercise indicated that while there were no differences between exercise conditions on perceptions of exertion, actual exertion was higher for the exercise-control participants than IVGT participants at each measurement period during exercise periods. No specific hypotheses were posited for actual and perceived exertion relationships across exercise conditions, however, several factors that may have accounted for these differences.

First, IVGT participants were pedaling in response to activity occurring in the video game. As such, they pedaled more often in sprint-like accelerations to coincide with vehicle acceleration strategies, so that even though participants kept their exercise intensity within their individual heart rate range, the nature of various acceleration/decelerations periods within the interactive exercise condition may have accounted for the trend toward higher exertion perceptions along with lower actual RPMs at each measurement period during exercise. In addition, while varying in their video game experience, all participants in the IVGT were novices within interactive video game exercise. With increased experience, participants in the interactive group may have been able to obtain greater pedal consistency through habituation, influencing their actual exertion.

Second, the use of more arm muscles to steer the ergometer during the interactive condition could have accounted for the greater RPE trend in IVGT participants. Both exercise conditions exercised on the interactive cycle ergometer with movable handlebars. However, since no video game was being played in the exercise control condition, there was no reason for arm steering movements. At the same time, IVGT participants may have incorporated slightly more upper body involvement in the exercise because arm muscles (to some extent) were involved to a greater degree in steering the video game vehicle. Therefore, for exercise-control participants, the lack of a video game may have made a steady pedal rate easier to maintain. Future research might include electromyography (EMG) assessments comparing specific muscle activity across different conditions to examine this notion.

Several limitations should be noted when interpreting this study. First, attempts were made to standardize conditions so that participants were scheduled and tested in pairs. This was done to standardize environmental conditions because the IVGT condition was set up to have two interactive exercise participants playing a video game concurrently in a split-screen format. However, scheduling restrictions of some participants limited the ability to test all participants in a paired format. As such, it is possible that affective changes for participants playing alone (against the video game) in the IVGT condition may have been different to changes occurring when participating with another while in the IVGT.

Second, the video game selected was the same for the IVGT and exercise-control conditions to control for differential changes in mood and concentration due to preferences for different video games. However, in everyday settings, the ability of individuals to self-select a preferred video game within an interactive setting may have a meaningful impact on affective changes through interactive video game exercise. The potential for meaningful impact on affective changes may be limited to only those individuals desiring racing-type video games. Current IVGT applications do not currently allow for other video game genres (i.e. shooting games like Halo, sport games, etc) which could be of interest to other individuals seeking exercise interfaced with video game technology. For IVGT exercise equipment to be effectively tailored to all types of gaming enthusiasts, the actual depth of gaming will need to be expanded.

Finally, in everyday exercise contexts, it is recommended that exercisers self-select an exercise mode that they prefer (Leith, 1998). Since the current design contained only one mode of aerobic activity (bicycling), the potential for mood benefits may have been limited by the fact that some participants may have been forced to participate in an exercise mode they would not have preferred or enjoyed as a self-selected mode of exercise. Since males and females had different rates of self-reported experience and frequency of video game use and research has shown differential rates of preference to engage in video games (Allison et al. 2005), future studies examining psychological effects of interactive video game exercise should control for gender and video game experience.

Educators are interested in direct learning outcomes that are derived from new, innovative, or different delivery methods. The increased sophistication of computer games have been thought to be potentially useful for instructional purposes and to provide multiple benefits including (1) diverse approaches to the learning process, (2) increased interactivity, (3) the ability to address cognitive and affective learning issues, and (4) increasing learners' motivation (O'Neil, Wainess, & Baker, 2005). Thus, IVGT exercise may have potential to indirectly enhance academic learning by enabling greater regular physical activity which is perceived as motivational and enjoyable to young adults.

The relation of physical activity and fitness to academic performance is of special concern to physical educators because many of these programs have been questioned regarding their contribution to the primary academic mission of schools. Evidence, however, supports that youth who are more physically active demonstrate better learning outcomes compared to those who are less physically active. For example, Dwyer, Sallis, Blizzard, Lazarus, & Dean (2001) examined scholastic performance and physical activity in a sample of 7,961 Australian schoolchildren and found that increased cardiorespiratory endurance, muscular force and power, and physical activity were all related to scholastic ability. Tremblay, Inmann, & Willis (2000) examined the relationship between children's reported levels of physical activity, body mass index, and reading/mathematics scores while controlling for sex, family structure and socioeconomic status. Their results showed that physical activity indirectly related to enhanced academic performance by improving physical health and self-esteem. Finally, longitudinal studies generally support that academic performance is maintained or enhanced by increases in students' levels of habitual activity. When substantial portions of curricular time (as much as 26%) are allocated to physical activity, learning has shown to proceed more rapidly per unit of classroom time, so that academic performance exceeds that of controls (Shephard, 1997). Thus, IVGT may hold meaningful potential to physical educators both directly, in presenting a motivational "entry point" to activity (Hayes & Silberman, 2007) and indirectly enhancing academic learning by enabling greater physical activity, especially among students who are not as motivated by traditional forms of physical activity.

In relating findings of the present study, since the effects of IVGT and exercise have been relatively unexamined, we wanted to first determine whether any positive psychological effects could be derived at all. Then, if the research supported affective benefits, consideration could begin as to transferring the IVGT exercise design into actual classroom settings. Considering that current results indicated that presence of IVGT did not differentially effect beneficial mood changes from exercise, suggestions for future studies are warranted. First, rather than use of college-age students as participants, affective benefits of IVGT may be more readily observed in younger, school-age children and adolescents (ages 8-18) for whom the technology is more sharply marketed towards. Second, future investigations should more directly examine possible short-term cognitive effects of IVGT exercise that may be reflected back to learning, such as short-term memory (STM) tests. Such a design could include pre-post measures of STM such as word-recall or digit span recall tests, which would have a more direct focus on STM aspects of learning capability. Finally, future designs should include qualitative measures of participants' perceptions of enjoyable/unenjoyable aspects of IVGT exercise. Several participants remarked that the format of directly competing against another person limited their enjoyment of the exercise. While the format (competitive vs. non-competitive) was not a formal independent variable examined in the current design, future research in this area might consider whether this format might lessen affective benefits, and its utility as a learning device for some individuals. Affective benefits may be enhanced when performed in a competitive format, depending on the achievement orientation of the individuals involved. For example, highly competitive individuals might find such activities more enjoyable and gratifying while others might be less motivated when competitive elements are salient.

## Conclusion

This study examined short-term psychological effects of interactive video game exercise in a controlled setting. The results supported that exercise had a positive benefit on mood states, but that presence of the video game technology did not appear to increase this mood enhancement. However, a case might be made for using IVGT in educational settings by physical educators, in that mood enhancement from the technology was similar to regular exercise. Physical educators may choose to integrate IVGT with children who have greater interest in video games, have a greater video game use, and who are less physically active, as a means of increasing their daily physical activity and enhancing their mood during the school day. Future research needs to examine whether psychological effects of IVGT become more pronounced with regular involvement over extended periods of time. In addition, from a physical education standpoint, further research may be warranted to compare student interest in and retention rates of IVGT exercise programs versus traditional exercise. Since exercise-based video game applications are marketed for their enjoyment factor, it may be that affective benefits from this activity are greater for young adults who are more experienced with video games. Since increased "screen time" activities are linked to a greater prevalence of overweight and obesity, this could have meaningful implications for young adults in these weight categories. Utilizing IVGT applications with populations already attracted to video games might induce greater interest in and affective benefits from that activity. Finally, results from this study indicate that while there is potential for interactive video game exercise to enhance motivation and affect, there is still need to examine conditions under which these possible benefits are most likely to occur.

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