

Psychophysiological and affective correlates of video game play

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ABSTRACT Recent research has examined how playing video games affects young adults, with some evidence that playing video games can have a positive effect on cognition. Mixed results have been shown with mood. The present study sought to further examine the effect of video game play, gender, and “gamer” status on physiological functioning, mood, and cognition. Participants were 85 undergraduate students (33 females, mean age 19.18 [SD = 2.10]) who played one of five video games (human violence, zombie violence, racing, sporting, non-violent) for 30 minutes. Blood pressure, heart rate, and mood were assessed before, during, and after game play. In addition, sustained attention was assessed after video game play. Results indicated that males responded to video game play more negatively than females, and “gamers” had less physiological reactivity to game play than non-gamers. The type of game played did not affect physiological, affective, or cognitive outcomes. Finally, females and “gamers” had better performance on a measure of sustained attention. The results of this study have implications for the use of video games in treatments for depression and social anxiety.

INTRODUCTION

Video games were invented for individuals to use the television as an active rather than passive instrument (“Television gaming apparatus and method,” United States Patents). Video games have come a long way, from games like Pong, Space Invaders, and Tetris, to newer games like Call of Duty. Many of the newer video games have a much more violent element, as, for example, players are tasked with killing enemy soldiers or organizing an invasion. What effect do these violent images and scenarios have on young players? Does the type of game played matter? The present study seeks to examine the effects of playing violent and nonviolent video games on heart rate, blood pressure, mood, and attention.

Video Games and Aggression

A review of multiple studies indicated that exposure to violent video games is positively correlated with heightened levels of aggression, as well as physiological arousal, in children and adults (e.g., Anderson & Bushman, 2001; Anderson & Dill, 2000; Anderson et al., 2010; Carnagey & Anderson, 2005; Kirsch, Olczak, & Mounts, 2005). Exposure to violent video games is also negatively correlated with prosocial behavior (helping and feeling empathy towards others; Anderson & Bushman, 2001). In addition, a study of EEG readings in male undergraduate students found that playing violent video games desensitizes individuals to violence and increases levels of aggression (Bartholow, Bushman, & Sestir, 2005). However, some studies have shown that individuals who play video games cooperatively show

increases in prosocial behavior and cooperative play (Ewoldsen et al., 2012; Greitemeyer & Osswald, 2009). In addition, playing cooperative online games improves social skills in children (Freddolino & Blaschke, 2008).

There have also been studies suggesting violent video games instead cause an increase in aggressive thoughts (Greitemeyer, Osswald & Brauer, 2010). For example, in a study of 345 adults who played video games, participants were randomly assigned to one of four conditions (low realism with high controller naturalness; low realism with low controller naturalness; high realism with low controller naturalness; high realism with high controller naturalness) while playing either Wii Sports: Boxing or Don King’s Showtime Boxing for a 10 minute tutorial followed by 15 minutes of gameplay. Results indicated that greater immersion in the game resulted in increased cognitive aggression (McGloin, Farrar, & Krmar, 2013). In a separate study of 83 adults (21 females) who played either a violent (Mortal Kombat vs. DC Universe, Resident Evil 5, Killzone 2, F.E.A.R. 2: Project Origin, or Call of Duty: Modern Warfare 2) or a non-violent video game (MotorStorm, NCAA Basketball: 2009, Sid Meier’s Civilization Revolution, Little Big Planet, or Ferrari Challenge) for 20 minutes, results indicated that acute exposure to violent video games (regardless of the type of game played) increased aggressive thoughts compared to those who played nonviolent games (Engelhardt, Bartholow, & Saults, 2011). In addition, individuals higher in trait anger were more susceptible to these effects (Engelhardt et al., 2011). Many studies only focus on violent versus non-violent video games with regard to

how playing video games affects level of aggression. The effects of playing different types of games should be examined. In addition, equal numbers of male and female participants should be utilized in studies to determine if gender plays a role in the relationship between video game play and outcome variables.

Video Games and Mood

There is relatively little research focused on how playing video games affects mood. In a study of 143 adults who played one of three video games (Bejeweled 2, Bookworm Adventures, or Peggle) for 20 minutes, it was found that mood significantly improved regardless of the type of video game played (Russoniello, O'Brian, & Parks, 2009). It should be noted that none of the games used in this study would be considered violent games. In a separate study of 103 adults, playing video games (Hitman: Blood Money, Call of Duty 2, or Madden 2007) for 45 minutes resulted in decreased feelings of hostility and depression in comparison to those in a no-game condition (completion of Paced Auditory Serial Addition Task, a measure of working memory capacity; Ferguson & Reuda, 2010). The games in this study could be classified as violent (Hitmen: Blood Money and Call of Duty 2) or sporting (Madden 2007). In a study of 13 male adults (ages 18-26) who completed a measure of state mood and played a violent video game (Tactical Ops: Assault on Terror) during five functional neuroimaging sessions, it was found that greater activity in the temporal lobe during failure events was linked with a reduced negative affect response to the game (Mathiak et al., 2011). In other words, losses in the video game environment were linked with real-world negative mood. There were no significant findings for positive affect. Still other studies have shown decreased longer-term outcomes (i.e., depression) following video game play (Weaver et al., 2009). The previous studies have very different findings, with some showing improved mood and others decreased mood. This conflicting finding may be due to the variety of video games used, and points towards examining different types of video games in the same study.

Video Games and Cognition

Although some studies show deficits in cognitive abilities following video game play (Hastings, Karas, Winsler, Way, Madigan, & Tyler, 2009), most have shown improvements in cognitive abilities. In a 14-week lon-

gitudinal study of primarily female older adults, those who played various games from Wii Sports showed significant benefits on executive tasks compared to a group of participants who completed two 1-hour exercise sessions every week for 12 weeks (Maillot, Perrot, & Hartley, 2012). Regardless of the type of game played, improvements due to video game play have been shown across various cognitive abilities (Barlett, Vowels, Shanteau, Crow, & Miller, 2009; Boot, Kramer, Simons, Fabiani, & Gratton, 2008; Cherney, 2008; Ferguson, 2007; Dye, Green, & Bavelier, 2009; Green & Bavelier, 2006). These changes can depend on "gamer" status—experts tend to have a baseline (i.e., prior to the study session) higher level of cognitive function than non-gamers (Boot et al., 2008). Although there is relatively little research focusing on video games and cognition, findings suggest that video games could have a positive effect on cognition.

The general aggression model (GAM) puts forth a way of understanding how playing violent video games can affect aggressive thoughts, behavior and cognition (Bushman & Anderson, 2002). In this model, playing violent video games is thought to cause an increase in aggressive beliefs, attitudes and behaviors. In turn, these increases in aggression also increase aggressive thoughts and cognitions. Based on this model, playing violent video games could have a negative effect on cognition because these aggressive thoughts could get in the way of completing tasks.

Video Games and Physiological Reactivity

Although some research has shown heart rate (HR) and blood pressure (BP) changes following violent video game play, results have been inconsistent. Some have found increased HR and BP after playing violent video games (Anderson & Dill, 2000; Ballard & Lineberger, 1999; Ballard & West, 1996; Carroll, Turner, & Rogers, 1987; Panee & Ballard, 2002), as well as increased skin conductance responses (Lim & Lee, 2009), all of which can indicate increased cardiovascular reactivity and/or aggression. Other researchers have found opposing results (Ballard, Hamby, Panee, & Nivens, 2006; Russoniello et al., 2009). In a study of primarily male adolescents who played one of three games (NBA Live, Resident Evil, or Mortal Kombat) over three weekly sessions of 15 minutes each, BP decreased over each gaming session while HR remained reactive to the game in-session (Ballard et al., 2006). These results in-

dicating that there may be some desensitization to the violence in video games over repeated playing. A second study supported these results. College students were randomly assigned to play one of four violent (Carnageddon, Duke Nukem, Mortal Kombat, or Future Cop) or non-violent (Glider Pro, 3D Pinball, 3D Munch Man, or Tetra Madness) games for 20 minutes with HR and galvanic skin responses taken every five minutes (Carnagey, Anderson, & Bushman, 2007). Next, they were shown a video of real violence for 10 minutes. Results showed desensitization to real violence after playing violent video games. Other studies have shown that physiological reactivity differs depending on gender, with increased variability among boys than girls (Ivarsson, Anderson, Akerstedt, & Lindblad, 2008).

Another series of studies of adolescents assessed different ways that video games could affect physiological functioning. In the first study, adults between the ages of 21 and 48 played either a racing (Burnout) or a non-racing (Tetris) game for 30 minutes, after which arousal was measured. During a second testing session, participants completed a measure of risk-taking, with results indicating that those who played the racing game took more risks in road traffic situations than those who played the non-racing game (Fischer et al., 2009). In the second study, a separate sample of adults played one of two different racing (Need for Speed, Burnout) or non-racing (Tak, Tetris) games prior to measuring driving-related risk-taking. Results again indicated higher levels of risk-taking in the racing game condition, regardless of the game played. In addition, players of racing games were more likely to perceive themselves as reckless drivers than players of neutral games (Fischer et al., 2009). In the final two studies, also using adult participants, results indicated that players of street racing games were more inclined to take risks in simulated critical road traffic situations than players of F1 driving and neutral games. In addition, participants who played a racing game perceived themselves more as a reckless driver than observers of racing games, players of neutral games, and observers of neutral games.

Other results show that playing video games can decrease heart rate and blood pressure (Ballard, Hamby, Panee, & Nivens, 2006); this may be because different games were used in the studies. This was a longitudinal study of mostly male adolescents. There were 3 weekly sessions and participants were assigned to play 1 of 3 video games (NBA Live, Resident Evil Director's Cut,

Mortal Kombat). We may also be seeing these differences because the studies mostly consist of males, and it is important to look at males and females equally.

THE PRESENT STUDY

Although much research has been conducted into the effect of playing violent video games on aggressive behaviors and thoughts, comparatively little research has examined how playing different types of video games affects mood, physiological reactivity, and attention. In addition, the gender of participants varies significantly across studies, with some including only male participants and others including at least some female participants. Does gender play a role in response to video games? It is possible that more male than female participants completed the previous studies due to the greater likelihood a male plays video games than a female, but it is not certain whether research involving mostly male participants relates to females. Also, does previous experience with video games, especially violent video games, affect results? Specifically, if someone is a self-identified "gamer," is physiological reactivity lessened to violent and non-violent game play? Can individuals become accustomed to playing games such that it has a calming/relaxing effect on the body? Finally, the research to date has overwhelmingly compared "violent" video game play to "nonviolent" video game play. Are all violent and non-violent games equivalent? It is important to consider these variables when researching video games as it could help clarify some of the conflicting results of previous studies. The present study seeks to examine how gender, knowledge of video games (i.e., video game expertise), and the type of game played affect outcomes.

Based on previous research several hypotheses were made. First, it was hypothesized that female participants would experience a greater level of physiological functioning and a lower level of mood during and following video game play than male participants. It was also hypothesized that individuals who self-identified as "gamers" (i.e., individuals with a high level of video game expertise) would show less of a physiological or affective response to video games than non-gamers. Finally, we sought to examine whether the type of game played differentially affected physiological reactivity, affect, and cognition.

METHOD

Participants

Participants were 85 undergraduate students (33 female, 70.0% Caucasian), ages 18 –31 (mean age = 19.18, SD = 2.10), enrolled in an Introduction to Psychology course in which credit is given for participation in psychology experiments. Students signed up for the study via an online sign-up system.

Measures

Heart Rate. The Finger Pulse Oximeter MD300C1 by Choicemed was used to measure heart rate. Participants placed the oximeter over the first finger of their dominant hand, and a reading was completed in less than 10 seconds. Accuracy is +/-2 beats per minute.

Blood Pressure. The Diagnostic EW3109 by Panasonic was used to measure systolic and diastolic blood pressure. Readings were taken by placing a blood pressure cuff over the arm, which then self-inflated to provide a blood pressure reading. Participants placed the blood pressure cuff on their dominant arm, and a reading was completed in less than 20 seconds.

Video Game History Questionnaire. This study-specific questionnaire assessed participants' history with video games. Questions asked about previous use of particular types of video games, frequency played, and whether the individual self-identified as a "gamer." Following game play, participants were asked how frustrating they found the game, on a 1 (not at all) to 5 (extremely) scale.

Positive and Negative Affect Schedule (PANAS). The PANAS measures current (state) positive and negative mood (Appendix C; Watson, Clark, & Tellegen, 1988). The 10-item positive affect subscale measures feelings of enthusiasm, activeness, and alertness (Watson et al., 1988). The 10-item negative affect subscale measures feelings of distress, such as anger, contemptuousness, fear, and nervousness (Watson et al., 1988). In terms of reliability, test-retest reliability after an 8-week interval was moderate (positive affect $\alpha = .54-.68$; negative affect $\alpha = .45-.71$; Watson et al., 1988). Negative affect scores are positively correlated and positive affect scores negatively correlated with the Beck Depression Inventory-II (Watson et al., 1988).

Conner's Continuous Performance Task. The Conner's Continuous Performance Task (CPT) measures symptoms and behaviors associated with adult Attention-Deficit/Hyperactivity Disorder (ADHD; Conners, 2000). Confidence index values above 50% indicate a

closer match to a clinical profile, and values below 50% indicate a closer match to a non-clinical profile. Values between 40% and 60% are inconclusive (Conners, 2000). In terms of reliability, split-half reliability is high ($\alpha = .66-.95$; Conners, 2000). 3-month test-retest reliability was moderate (Conners, 2000). Individuals with ADHD scored higher than individuals without ADHD, with 87% specificity (Conners, 2000). There is a positive correlation between CPT scores and self-reported ADHD symptoms (Conners, 2000). Dependent variables included total performance (determined by likelihood of ADHD diagnosis) and detectability (accurate detection of the target stimulus in milliseconds).

Video Games. Several different types of video games were examined in the present study. Dead Island is a first-person shooter zombie game. It has a close-quarters melee focus in which zombies can attack the player from all directions. Call of Duty: Modern Warfare 3 is also a first-person shooter in which American forces fight a Russian forces invasion. LittleBigPlanet is a non-violent game that allows the player to explore a world of sock-puppet creatures and interact with the environment. Need For Speed: Hot Pursuit is a high energy racing game that allows players to race high-performance vehicles against other racers, as well as earn points by evading and destroying pursuing police vehicles. NBA2K12 is a sporting game in which participants take on the role of professional basketball players in shortened games. For each game, all participants played the same levels/courses in the same order.

PROCEDURE

Students enrolled in psychology courses that provided credit for research participation saw information about the study on an online sign-up system. They were provided with information about the potential use of violent video games in the study, and interested participants were able to sign-up for a session. Prior to the scheduled sessions, all participants were randomly assigned to play one of five video games: violent (Call of Duty: Modern Warfare 3), zombie violent (Dead Island), non-violent (Little Big Planet), sporting (NBA2K12) or racing (Need for Speed: Hot Pursuit).

Upon arrival at the experimental session, all participants provided written informed consent. Baseline blood pressure (BP) and heart rate (HR) readings were taken. Next, participants completed a series of questionnaires, presented in a random order, including the

video game history questionnaire and the PANAS. Participants were then given a tutorial on the assigned video game, including information regarding play controls and how to start/pause/stop the game. HR and BP were again measured prior to video game play. During video game play, a depiction of the game controller with the appropriate controls for the selected game was provided for each participant's reference, if needed. Each participant then played the assigned game for 30 minutes. BP and HR were monitored at five-minute intervals. After completion of video game play, participants completed a second administration of the PANAS, the CPT, and several additional tasks as part of a larger study. HR and BP were monitored every 15 minutes during the remainder of the study session. At the end of the session, participants were debriefed and given course credit for their participation.

DATA ANALYSIS

The hypotheses were tested as follows. To assess for gender differences in HR, BP, mood, and attention, a series of independent-samples t-tests were conducted. To assess for "gamer/non-gamer" (as determined by self-report) differences in these variables, a second set of independent-samples t-tests were conducted. To assess whether the type of game played mattered, a series of one-way ANOVAs were conducted, with type of game as the between-subjects variable. Specific game-type hypotheses were then assessed utilizing results of post-hoc analyses. The dependent variables were as follows: HR (average of two measurements before video game play, average of six measurements during video game play, average of two to four measurements after video game play), BP (average of two measurements before video game play, average of six measurements during video game play, average of two to four measurements after video game play), mood (measured before and after video game play), and attention (total performance and detectability). BP was broken down into systolic (top number; pressure when the heart beats) and diastolic (bottom number; pressure between heart beats) for ease of data analysis.

RESULTS

Gender Results

More men (52) than women (33) completed the study. More men than women self-identified as "gamers," $t(80) = -3.731, p < .001$. Females found the

games more frustrating than males, $t(80) = 3.165, p = .002$. In terms of HR, there were no significant findings prior to, $t(81) = 1.691, p = .095$; during, $t(81) = 0.157, p = .876$; or after, $t(78) = 0.635, p = .527$, video game play. Significant differences were found for BP (systolic): men had higher BP values than women before, $t(79) = -2.996, p = .004$; during, $t(79) = -3.892, p < .001$; and after, $t(75) = -2.787, p = .007$, video game play. No differences were found for BP (diastolic) at any of the time points ($ps > .124$). Prior to video game play, men were in a more positive mood than women, $t(81) = -2.592, p = .011$; however, there were no differences between genders in positive mood after video game play, $t(77) = -0.895, p = .374$. In terms of negative mood, there were no differences prior to video game play, $t(81) = -0.386, p = .701$; but men endorsed higher negative mood following video game play than women, $t(77) = 2.446, p = .017$. On the CPT, no significant differences emerged in total performance, $t(58) = 0.182, p = .856$, but women had better detectability than men, $t(58) = -1.582, p = .050$.

Gamer Results

All participants reported a history of playing video games, but only 70/85 indicated they currently play video games. 46/85 self-identified as a "gamer." No differences emerged in positive, $t(82) = -1.868, p = .065$, or negative, $t(82) = -0.743, p = .460$, mood prior to game play. After game play, there were again no differences in mood between groups (positive: $t(78) = -1.341, p = .184$; negative: $t(78) = 0.602, p = .549$); however, non-gamers found the games more frustrating than did gamers, $t(81) = 2.431, p = .017$. In terms of HR, non-gamers had higher HR prior to, $t(82) = 2.339, p = .022$, and during, $t(82) = 2.256, p = .027$, game play than gamers. No differences were seen in HR after game play, $t(79) = 1.279, p = .205$. No significant differences were found for BP (systolic) before, $t(80) = -1.294, p = .199$; during, $t(80) = -1.490, p = .140$; or after, $t(76) = 0.092, p = .927$ video game play. No significant differences were found for BP (diastolic) at any of the time points ($ps > .139$). On the CPT, no significant differences merged between groups on detectability, $t(59) = 0.325, p = .746$, but gamers had better overall performance than non-gamers, $t(59) = 2.000, p = .050$.

Type of Game Results

Due to the small sample size of the game type

Variable	Males	Females	Gamer	Non-Gamer
<i>N</i>	51	33	45	39
Pre- measures:				
PANAS-P	3.18 (0.76) ^b	2.74 (0.80)	3.14 (0.73)	2.84 (0.86)
PANAS-N	1.57 (0.57)	1.53 (0.56)	1.59 (0.60)	1.50 (0.52)
BP-Top	128.21 (10.41) ^a	121.33 (9.48)	127.20 (11.38)	123.93 (10.21)
BP-Bottom	76.82 (8.53)	75.45 (7.08)	77.33 (6.52)	74.89 (9.12)
HR	71.80 (10.07)	75.98 (12.10)	70.68 (9.10) ^d	75.88 (11.41)
During measures:				
BP-Top	125.15 (8.80) ^a	117.44 (8.67)	123.63 (8.47)	121.08 (10.74)
BP-Bottom	78.50 (6.90)	76.06 (7.67)	78.35 (6.45)	76.53 (7.80)
HR	71.97 (9.04)	72.34 (10.58)	69.62 (8.05) ^d	74.13 (10.13)
Post- measures:				
PANAS-P	3.05 (0.86)	2.88 (0.94)	3.08 (0.82)	2.84 (0.94)
PANAS-N	1.41 (0.45) ^b	1.74 (0.71)	1.48 (0.50)	1.57 (0.66)
Frustration	2.18 (1.03)	2.97 (1.20)	2.22 (1.00)	2.82 (1.23)
BP-Top	125.19 (11.16) ^a	117.38 (11.72)	122.29 (10.35)	121.35 (14.39)
BP-Bottom	78.16 (10.14)	76.26 (8.89)	75.95 (8.48)	78.93 (10.60)
HR	69.11 (10.77)	70.54 (10.74)	68.14 (10.10)	70.67 (10.44)
CPT Detect	55.69 (8.85) ^c	59.71 (5.48)	56.68 (8.56)	57.55 (7.11)

^aMen > Women, $p < .01$; ^bMen > Women, $p < .05$ ^cWomen > Men, $p < .05$;

^dGamer > Non-Gamer, $p < .05$.

Note: PANAS = Positive and Negative Affect Schedule, Positive (P) and Negative (N); BP =

blood pressure; HR = heart rate; CPT = Continuous Performance Task, Detectability (Detect).

Table 1. Study variables presented as mean (standard deviation).

groups, the following analyses should be considered exploratory. No differences were seen between groups in positive [$F(4,80) = 0.611, p = .656$] or negative [$F(4,80) = 0.162, p = .957$] mood before the video game was played, nor in positive [$F(4,76) = 1.812, p = .135$] or

negative [$F(4,76) = 1.924, p = .115$] mood after video game play. In addition, there were no game-type differences in level of frustration with the game play, $F(4,79) = .885, p = .477$. There were no significant differences between video game groups on average blood pressure

Variable	Violent	Zombie	Racing	Non-Violent	Sporting
<i>N</i>	21	18	17	15	14
Pre- measures:					
PANAS-P	3.04 (0.60)	3.00 (0.67)	2.79 (1.05)	3.22 (0.94)	3.13 (0.77)
PANAS-N	1.61 (0.53)	1.51 (0.42)	1.59 (0.61)	1.49 (0.46)	1.54 (0.84)
BP-Top	127.85 (10.75)	123.00 (6.45)	130.18 (11.88)	125.67 (15.35)	123.77 (10.19)
BP-Bottom	77.85 (6.80)	75.11 (6.10)	78.62 (10.01)	74.23 (10.02)	77.59 (6.76)
HR	77.24 (10.36)	72.47 (11.73)	73.85 (10.67)	69.57 (10.24)	71.13 (8.75)
During measures:					
BP-Top	122.75 (9.37)	120.36 (7.27)	124.35 (11.08)	125.11 (9.35)	122.26 (11.07)
BP-Bottom	78.74 (7.66)	76.65 (5.91)	78.19 (7.97)	78.00 (7.75)	77.47 (7.21)
HR	74.88 (8.13)	71.37 (11.40)	72.00 (8.69)	68.49 (8.68)	68.00 (9.32)
Post- measures:					
PANAS-P	3.04 (0.70)	2.80 (0.95)	3.46 (0.94)	2.84 (0.90)	2.89 (0.80)
PANAS-N	1.64 (0.64)	1.49 (0.44)	1.72 (0.79)	1.20 (0.25)	1.60 (0.56)
Frustration	2.43 (1.40)	2.61 (1.20)	2.47 (0.94)	2.07 (1.03)	2.85 (0.99)
BP-Top	122.76 (10.84)	123.00 (8.52)	123.06 (14.11)	121.25 (15.52)	119.69 (9.29)
BP-Bottom	75.86 (7.60)	81.11 (11.88)	79.06 (11.91)	73.67 (4.37)	76.85 (5.32)
HR	73.53 (11.03)	69.50 (11.40)	70.83 (9.24)	64.58 (9.29)	68.00 (9.32)
CPT Detect	58.03 (8.29)	55.80 (7.72)	56.31 (10.38)	57.22 (6.69)	58.43 (5.38)

Note: PANAS = Positive and Negative Affect Schedule, Positive (P) and Negative (N); BP =

blood pressure; HR = heart rate; CPT = Continuous Performance Task, Detectability (Detect).

Table 2. Video game data presented as mean (standard deviation).

es in the game environment. Thus, no support exists to show that females have a worse response to video game play than males.

Second, it was hypothesized that gamers would show less physiological and mood response than non-gamers. Our results partially support this hypothesis. Non-gamers showed higher HR than gamers before and during game play, but no differences were found after game play. In addition, no differences were found for BP before, during, or after game play, or in positive or negative mood between gamers and non-gamers. Comparing self-reported state mood between gamers and non-gamers has not been specifically addressed in the literature, which has instead focused on HR and BP (Anderson & Dill, 2000; Ballard & Lineberger, 1999;

possible that the level of violence in each of the games negated any differences in the content between games. On the other hand, differences in how the games were played (i.e., first-person shooter with distant combat; first-person shooter with up-close combat; racing; side-to-side play) could have affected participant reactions.

For the CPT, our findings suggest that women were more accurate than men, and that gamers had better overall performance when compared to non-gamers. These two findings may be related since more men self-identified as gamers than did women. When looking at the type of game played and performance on the CPT, there were no significant findings. The present results are consistent with previous findings in which cognitive abilities, including working memory, selective

attention, visuospatial perception, and task switching, improved regardless of the type of video game played (Barlett et al., 2009; Boot et al., 2008; Cherney, 2008; Dye et al., 2009; Ferguson, 2007; Green & Bavelier, 2006). The results are also consistent with findings from another study where experts tended to have a baseline higher level of cognitive function than non-gamers (Boot et al., 2008). Taken together, the present findings suggest that playing video games can improve cognition.

LIMITATIONS

There were several limitations to this study. We did not have high quality HR and BP monitoring equipment. If we were to have better equipment we may have been better able to determine more subtle differences in physiological reactivity. One of our biggest limitations was the fact that we did not have an equal number of female gamers to male gamers as well as females to males in general. We may not have been able to accurately compare groups due to unequal sample sizes. With a larger sample size, these factors could have been more fully assessed. It is possible that the different video games used in the present study were not equivalent in terms of engagement and interest, in turn affecting how invested participants were in the game and its outcome.

In the beginning of data collection, participants were not able to complete all the study tasks due to time constraints. This may have affected our results because that lowers the amount of people for each task that were assigned for after game play. We also did not limit caffeine or nicotine use before the study, both of which could have affected physiological functioning. Lastly we did not record the quality and amount of sleep for the night before the study. This could have affected our results because if participants did not sleep enough or very well, they could have performed poorly on cognitive and attention tasks, such as the CPT. Collectively, these potential limitations may have negatively affected our results.

CONCLUSIONS

Collectively, the present findings suggest improved cognition among self-identified gamers, worse mood among males following game play, and higher heart rate in non-gamers before and during game play. Many of these findings fit into the current literature as they confirm and extend previous results showing improved

cognition due to video game play. However, the finding that only males experienced a decrease in mood is novel and warrants additional research to determine if this is due to the losses in the game or to some other factor. The present study has implications for students, as it shows that playing video games can help increase cognitive performance, and future research should examine whether video game play can improve or impair academic performance in general. Before video games are used as a treatment for depression, social anxiety, and other disorders, additional research is needed to determine why males may experience a negative reaction to game play. In addition, the use of multiple different violent and non-violent video games in the same study would allow for a more in-depth analysis of the effects of video game play, independent of the specific game used.

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