



The influence of video games on executive functions in college students



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ABSTRACT

Video game play can have a negative effect on affect and behavior, but its relationship with cognition has been mixed. Previous research has shown both positive and negative effects of video game play on attention, memory, and other cognitive abilities; however, little research has investigated its effects on executive functions other than working memory. Additionally, most studies have utilized predominantly male samples. The present study sought to examine the effects of active video game play on decision making, problem solving, and risk-taking. Two hundred twenty-eight undergraduate students (114 female) played one of five different video games ($n = 91$) or were part of a separate, no-game control condition ($n = 137$). Scores on the Iowa Gambling Task (IGT), Balloon Analogue Risk Task (BART), and Wisconsin Card Sorting Task (WCST) were then compared. Following active video game play, participants decided more advantageously on the IGT, and made fewer errors and completed more categories on the WCST. No group differences emerged on the BART, and gender did not impact any dependent variables. It appears that active video game play may have positive effects on some executive functions with implications for real-world behavior. Implications for future research are discussed.

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1. Introduction

Much research has examined the effects of video game play on cognition and behavior (see [Anderson, 2004](#); [Anderson & Bushman, 2001](#); [Barlett, Anderson, & Swing, 2009](#); for reviews). Most of these studies have focused on the negative consequences of violent video games, such as increased aggressive behaviors, negative affect, and negative cognitions ([Anderson, 2004](#); see [Okdie et al., 2014](#), for discussion). However, other research has highlighted some benefits of video game play such as prosocial behavior ([Ewoldsen et al., 2012](#); [Velez, Mahood, Ewoldsen, & Moyer-Guse, 2014](#)). While these studies have added much to our understanding of how violent video games affect cognition, few studies have examined how video game play affects performance on clinical measures of executive functions. The present study sought to examine the effects of video game play on executive functions.

1.1. Executive functions

Executive functions refer to higher-order cognitive abilities tied to the frontal lobes of the brain, and encompass such abilities as

planning, organization, set shifting, problem solving, working memory, and decision making ([Lezak, Howieson, & Loring, 2004](#)). Multiple theories have been put forth regarding the organization of executive functions. One theory is that executive functions comprise a single construct, the central executive, that helps organize these higher-order cognitive abilities ([Della Sala, Gray, Spinnler, & Trivelli, 1998](#)). Others have proposed a multiple-systems approach to understanding executive functions. [Anderson \(2002\)](#) proposed a four-process model that includes: (1) cognitive flexibility (including working memory and divided attention), (2) goal setting (including planning and initiation), (3) information processing (including fluency and speed of processing), and (4) attentional control (including self-regulation and self-monitoring). Anderson indicated that these four subsystems integrate together to form one overall executive control system. [Diamond \(2013\)](#) proposed a three-factor model of executive functions in which inhibition, working memory, and cognitive flexibility worked together to influence higher-order executive functions such as reasoning, planning, and problem solving. The tasks utilized in the present study assess problem solving and decision making, both of which could be considered higher-order executive functions per [Diamond's \(2013\)](#) model.

1.2. Video games and cognition

Despite the vast number of studies examining video games and cognition, no clear pattern has emerged. The data suggest that

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video game play can both benefit and hinder cognition. For example, some studies have shown improvements in visual (Blacker & Curby, 2013; Boot, Kramer, Simons, Fabiani, & Gratton, 2008; Feng, Spence, & Pratt, 2007; Green & Bavelier, 2003, 2006) and selective attention (Belchior et al., 2013; Donohue, Woldorff, & Mitroff, 2010; Green & Bavelier, 2006; Karle, Watter, & Shedden, 2010; McDermott, Bavelier, & Green, 2014), including decreased change blindness (Vallett, Lamb, & Annetta, 2013). Conversely, others have found diminished attention (Kronenberger et al., 2005) or have failed to find differences in attention from control participants (Bailey, West, & Anderson, 2010; Collins & Freeman, 2014; Irons, Remington, & McLean, 2011; Wilms, Petersen, & Vangkilde, 2013). Additionally, the results of some previous studies indicate that frequent video game play increases attentional problems in children (Acevedo-Polakovich, Lorch, & Milich, 2007; Chan & Rabinowitz, 2006; Christakis, Zimmerman, DiGiuseppe, & McCarty, 2004; Swing, Gentile, Anderson, & Walsh, 2010). Thus, it is possible that video game play, especially in adolescents and young adults who are frequent players, decreases attentional resources in turn negatively affecting executive functions. However, a significant number of studies have shown the opposite—improved attention and executive functioning due to video game play. It is unclear what role video game play has in the development (or worsening) of attentional symptoms in young adults and children.

Despite the fragmentation in the literature on video games and cognition, one consistent finding continues to emerge in the visuospatial realm. Across multiple studies, improvements in mental rotations (De Lisi & Wolford, 2002; Greenfield, Brannon, & Lohr, 1994; Okagaki & Frensch, 1994; Passig & Eden, 2001) and visuospatial tasks more generally (Boot et al., 2008; Feng et al., 2007; Ferguson, 2010; Green & Bavelier, 2003) are seen as a function of video game play, regardless of the game type. Reaction times are faster and more accurate as a function of both recent video game play (Fischer, Kubitzki, Guter, & Frey, 2007) and a history of frequent video game play (Colzato, van den Wildenberg, Zmigrod, & Hommel, 2013). Thus, it appears that video game play may affect different cognitive abilities in positive and negative ways.

1.3. Video games and executive functions

Video game play affects performance on measures of executive functions as well. Within the video game literature, most studies show improved performance on executive tasks (see Kirsh, Olczak, & Mounts, 2005, for exception). For example, improvements have been shown on tasks assessing such executive functions as inhibitory control, task/set shifting, working memory, and abstract reasoning as a function of video game play (Basak, Boot, Voss, & Kramer, 2008; Boot et al., 2008; Maillot, Perrot, & Hartley, 2012; Mathews et al., 2005; Stern et al., 2011). Neuroimaging studies conducted before and after two (Kuhn, Gleich, Lorenz, Lindenberger, & Gallinat, 2014) and four (Colom et al., 2012) months of video game play in “non-gamers” showed increases in gray matter in the frontal lobe. These increases are localized to the dorsolateral prefrontal cortex (DLPFC), an area associated with abstract reasoning and problem solving (Lezak et al., 2004) as well as decision making in some studies (Fellows & Farah, 2005; Manes et al., 2002).

Decision making is a specific executive function that has been extensively researched in patient and non-patient populations, but is rarely examined in the context of video game play. At the most basic level, decision making involves a choice between two or more options. Decision making can occur through calculated and deliberative reasoning, or can be based at least in part on “gut feelings” and emotions (Damasio, 1994; Seguin, Arseneault, & Tremblay, 2007). When decision making relies primarily on

emotions and leads toward negative outcomes, this has been referred to as risky decision making (i.e., continued risky decisions even after the risks associated with those decisions is known to the individual; Bechara, 2008). Although not directly assessing decision making, Fischer et al. (2007) found increased risk-taking cognitions following 20 min of active video game play. Only one previous study has examined video games and risky decision making (Bailey, West, & Kuffel, 2013). Bailey and colleagues examined self-reported hours of video game play and performance on the Iowa Gambling Task (IGT; Bechara, Damasio, Damasio, & Anderson, 1994), the most common behavioral measure of risky decision making, as well as a delay discounting task and a self-report measure of impulsivity. Participants reporting higher levels of video game play were more impulsive, preferred smaller but more immediate rewards to larger but more temporally distant rewards, and failed to learn to choose advantageously on the IGT (i.e., continued to engage in risky decision making).

However, two large issues exist with the current literature on the effects of video games on executive functions and in studies of cognition in general. First, the majority of the published studies utilize samples composed of only or predominantly male participants (Bailey et al., 2010; Blacker & Curby, 2013; Boot et al., 2008; Collins & Freeman, 2014; Colzato et al., 2013; Donohue et al., 2010; Green & Bavelier, 2006; Wilms et al., 2013). Of those studies utilizing predominantly male samples, only one study examined results with and without female participants, finding no differences after the 15 females were removed from the analyses (leaving 106 males; Blacker & Curby, 2013). A second issue with the current literature is that a significant number of previous studies have been correlational in nature, examining how a previous history of video game experience affects cognition, not how active game play affects cognition (Bailey et al., 2010; Blacker & Curby, 2013; Collins & Freeman, 2014; Colzato et al., 2013; Donohue et al., 2010; Feng et al., 2007; Karle et al., 2010; McDermott et al., 2014; Vallett et al., 2013; Wilms et al., 2013). Thus, it is possible that females may respond differently on cognitive tasks following video game play than males, and pairing these cognitive tasks with active game play (rather than self-reported game play) may provide a more fine-grained picture of the effects of video games on executive functions.

1.4. The present study

The present study sought to examine the influence of active video game play on executive functions in both male and female undergraduate students. According to some research, video game play should lead to worse outcomes on clinical measures of cognition and possibly executive functions. In contrast, other research suggests that video game play might instead lead individuals to perform better on formal measures of executive functions. The present study examined these two competing theories by assessing decision making, risk-taking, and problem solving following 30 min of active video game play. As the effects of video game play on cognition in female participants has not been widely examined in the research to date, our analyses regarding gender differences are largely exploratory in nature.

2. Method

2.1. Participants

Participants were 228 undergraduate students (114 females; $M_{\text{age}} = 19.23$, $SD_{\text{age}} = 2.59$) enrolled in psychology courses at a regional campus of a large Midwestern university and for which

course credit was given for participation in research studies. Most (73%) self-identified as Caucasian.

2.2. Measures

2.2.1. Positive and negative affect schedule

The Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988) was utilized to assess between-groups differences in mood prior to the executive tasks. Previous research has shown relationships between mood and decision making (i.e., Buelow, Okdie, & Blaine, 2013; Buelow & Suhr, 2013; Forgas, 1995; Smoski et al., 2008; Suhr & Tsanadis, 2007). On the PANAS, participants respond to positive (10 items) and negative (10 items) statements regarding current mood. Average scores were calculated, with higher scores indicating higher levels of the mood state. Internal consistency was high for both subscales ($\alpha = .91$ positive; $\alpha = .86$ negative).

2.2.2. Iowa gambling task

The Iowa Gambling Task (IGT) was created to assess decision making impairments among individuals who engaged in real-world risky decision making yet showed no impairments on formal neuropsychological testing (Bechara et al., 1994). The IGT version available through PAR, Inc. was utilized in the present study (Bechara, 2008). On this task, participants are given 100 trials in which to maximize their profit by selecting from one of four decks: A, B, C, and D. They are not told anything about the decks, and must learn which are “good” and which are “bad” through trial-and-error selections. Decks A and B return an average profit of \$100 per selection, whereas Decks C and D average a profit of \$50 per selection (Bechara, 2008). However, losses can also occur. After 10 selections from Decks A or B, participants have incurred a loss of \$250. After 10 selections from Decks C and D, participants have instead gained \$250. Based on these long-term outcomes, Decks A and B have been termed disadvantageous and Decks C and D advantageous (Bechara, 2008; Bechara et al., 1994). Validity of the IGT has been shown through clinical and nonclinical populations (Buelow & Suhr, 2009).

Although the IGT has been referred to as a measure of risky decision making, previous research has suggested that the type of decision making assessed changes as the task progresses. During the early trials, when participants do not know much about the decks, decisions are made under ambiguity: participants are making decisions based on limited information about risks/benefits (Brand, Recknor, Grabenhorst, & Bechara, 2007). After approximately 40 trials, participants have learned enough about the decks to estimate the risks/benefits of their selections, and instead utilize decision making under risk (Brand, Recknor, et al., 2007; Ko et al., 2010; Noel, Bechara, Dan, Hanak, & Verbanck, 2007). In the present study, the number of advantageous minus disadvantageous selections was calculated for each of the five, 20-card blocks of trials (Trials 1–20: Block 1; Trials 21–40: Block 2; Trials 41–60: Block 3; Trials 61–80: Block 4; Trials 81–100: Block 5), in which positive values indicate more advantageous decision making. The IGT manual recommends this scoring approach (Bechara, 2008).

2.2.3. Balloon analogue risk task

The Balloon Analogue Risk Task (BART) was created to assess risk-taking behavior in adolescents and young adults (Lejuez et al., 2002). Studies showing little to no correlations between performance on the IGT and BART support the distinction that the IGT measures decision making under ambiguity and decision making under risk (risky decision making) and the BART measures pure risk-taking (Aklin, Lejuez, Zvolensky, Kahler, & Gwadz, 2005; Buelow & Blaine, in press; Lejuez et al., 2003). On the BART, participants are presented with 30 balloons, one at a time, and are asked

to make money by pumping up the balloons. Each pump earns the participant five cents, which is stored in a temporary bank (Lejuez et al., 2002). However, balloons will pop if they are pumped too much. If the balloon pops, participants lose all of the money stored in the temporary bank and the next balloon appears. In order to keep the money, participants must stop before the balloon pops and click the “Collect \$\$\$” button, transferring the money in the temporary bank to the permanent bank (Lejuez et al., 2002). The balloons can pop at any time, but the average breaking point is 64 pumps (unknown to the participants; Lejuez et al., 2002). Validity for the task is shown through correlations with real-world risk-taking behaviors and personality characteristics (Aklin et al., 2005; Bornovalova et al., 2009; Hopko et al., 2006; Hunt, Hopko, Bare, Lejuez, & Robinson, 2005; Swogger, Walsh, Lejuez, & Kosson, 2010). Here, the average number of pumps adjusted for only the unexploded balloons (as it is unknown how far the participant would have gone if the balloon did not pop) was calculated.

2.2.4. Wisconsin card sorting task

The Wisconsin Card Sorting Task (WCST) was created to assess executive functions, specifically problem solving, abstract thinking, and cognitive set shifting (Heaton, Chelune, Talley, Kay, & Curtiss, 2005). Participants are asked to match a set of cards to one of four key cards, utilizing feedback on each trial to determine the sorting principle. As the task progresses, the sorting principle changes, and participants must adapt their responses to complete the task. To successfully complete the task, participants must complete six categories/sorting principles. Correlations have been shown between the WCST and other measures of executive functions, including decision making (Brand, Grabenhorst, Starcke, Vandekerckhove, & Markowitsch, 2007; Brand, Recknor, et al., 2007). The dependent variables in the present study included the total number of errors and the total number of categories completed.

2.3. Procedure

The present study was approved by the University's Institutional Review Board. Participants were split into one of two groups: 137 in the control group and 91 in the video game group. Participants in the video game group first completed a series of questionnaires assessing various personality and other characteristics, then were randomly assigned to play one of five video games (*Call of Duty: Modern Warfare 3*, *Dead Island*, *LittleBigPlanet*, *NBA2K12*, *Need for Speed: Hot Pursuit*) as part of a larger study of psychophysiological responses to video games (Cooper & Buelow, 2014). The games varied in their level of violence, content, and gameplay, and were chosen to ensure that effects were not due to a single aspect of one particular video game. Participants were first given a brief tutorial on how to play the game, had access to a “key” indicating which button was tied to which action, and practiced game play for 5 min. Then, participants played the assigned video game for 30 min, followed by completion of the PANAS. The IGT, BART, and WCST were then completed in a counterbalanced order. As cognitive outcomes were a secondary aim of the overall study, not all participants completed all three tasks due to time constraints. Among the video game group, 82 completed the IGT, 85 the BART, and 45 the WCST.

Participants in the control group first completed a series of other questionnaires and cognitive tasks, followed by the PANAS, IGT, BART, and WCST presented in a counterbalanced order. Participants in the control group were compiled from other research studies running concurrently in which the IGT, BART, and/or WCST were administered, resulting in different sample sizes on each task. Among the control group, 135 completed the IGT, 135 the BART, and 71 the WCST.

2.4. Data analysis

First, performance on the cognitive tasks was examined for between-game differences among the video game participants. No significant differences were found in cognitive task performance by video game type ($ps > .15$), so video game type was collapsed into one video game group for the remaining comparisons. Data were then examined for between-group differences on demographic variables. To test the hypotheses, a series of 2 (group: video game, control) by 2 (gender: male, female) factorial ANOVAs were conducted on the cognitive task variables.

3. Results

3.1. Demographic and mood results

There were no significant differences in gender, $\chi^2(1, N = 216) = 0.284, p = .594$; or age, $t(203) = 0.292, p = .771$; between the video game and control groups. The groups did not differ in positive ($p = .087$) or negative ($p = .729$) mood prior to the cognitive tasks. Means and standard deviations for the study variables can be found in Table 1. To assess mood effects on the tasks independent of video game group, correlations were calculated between scores on the PANAS and the IGT, BART, and WCST. No significant correlations emerged with the PANAS-positive ($ps > .14$). For the PANAS-negative, only the correlation with IGT Block 5 was significant ($r = -.147, p = .033$; remaining $ps > .18$).

3.2. Executive function results

On the IGT, the group by gender interaction was not significant for Block 1, $F(1,203) = 0.069, p = .793$. In addition, neither the main effect of group, $F(1,203) = 0.006, p = .936$, or gender, $F(1,203) = 0.857, p = .356$, was significant. On Block 2, the interaction, $F(1,203) = 0.813, p = .368$, and main effect of group, $F(1,203) = 0.547, p = .460$, were not significant. The main effect of gender was marginal, $F(1,203) = 3.420, p = .066, \eta_p^2 = .017$, indicating a trend toward males selecting more advantageously than females on Block 2. For Block 3, only the main effect of group was significant, $F(1,203) = 4.027, p = .046, \eta_p^2 = .019$ (gender: $F(1,203) = 1.753, p = .187$; interaction: $F(1,203) = 0.394, p = .531$).

Table 1
Study variables by video game group.

Variable	Control M (SD)	Video game M (SD)	Test statistic	p
Age	19.28 (2.60)	19.17 (2.58)	0.29	.77
Gender	51% F	48% F	0.28	.59
PANAS-P	2.75 (0.83)	2.94 (0.83)	-1.72	.09
PANAS-N	1.51 (0.54)	1.54 (0.55)	-0.35	.73
<i>IGT</i>				
Block 1	-3.13 (6.40)	-3.07 (5.85)	-0.06	.95
Block 2	-0.16 (6.33)	0.89 (6.18)	-1.20	.23
Block 3	0.25 (7.69)	2.56 (7.02)	-2.22	.03
Block 4	0.63 (8.46)	2.83 (7.76)	-1.92	.06
Block 5	1.04 (9.37)	2.15 (8.65)	-0.87	.39
<i>BART</i>				
	28.10 (12.09)	29.90 (11.56)	-1.09	.28
<i>WCST</i>				
Errors	28.15 (21.07)	19.44 (11.90)	2.53	.01
Categories	5.20 (1.46)	5.78 (0.67)	-2.50	.01

Note: Bold values indicate significance at the $p = .05$ level. PANAS = Positive and Negative Affect Schedule; IGT = Iowa Gambling Task, number of advantageous minus disadvantageous selections by 20-card block of trials; BART = Balloon Analogue Risk Task, average number of pumps per balloon adjusted for only unexploded balloons; WCST = Wisconsin Card Sorting Task, number of errors and categories completed.

On Block 3, participants in the video game group selected significantly more advantageously than participants in the control group. A similar pattern emerged on Block 4. The main effect of gender, $F(1,203) = 0.852, p = .357$, and the group by gender interaction, $F(1,203) = 0.002, p = .963$, were not significant. The main effect of group on Block 4 was marginal, $F(1,203) = 3.405, p = .066, \eta_p^2 = .016$, indicating a trend toward participants in the video game group continuing to select more advantageously than those in the control group. Finally, on Block 5, the main effect of gender, $F(1,203) = 0.627, p = .429$; main effect of group, $F(1,203) = 1.073, p = .302$; and group by gender interaction, $F(1,203) = 0.196, p = .658$; were not significant.

Finally, the BART and WCST were examined. On the BART, no main (group: $F(1,206) = 0.627, p = .429$; gender: $F(1,206) = 0.702, p = .403$) or interaction, $F(1,206) = 0.640, p = .425$, effects were significant. On the WCST, individuals in the video game group had significantly fewer errors than individuals in the control group, $F(1,104) = 5.296, p = .023, \eta_p^2 = .048$. The main effect of gender, $F(1,104) = 0.002, p = .968$, and the group by gender interaction, $F(1,104) = 0.099, p = .754$, were not significant. Participants in the video game group also completed more categories on the WCST than participants in the control group, $F(1,104) = 6.628, p = .011, \eta_p^2 = .060$. The main effect of gender, $F(1,104) = 1.291, p = .258$, and the group by gender interaction, $F(1,104) = 0.194, p = .660$, were not significant.

4. Discussion

The present study sought to examine two competing lines of research into video games and cognition: one indicating worse cognitive performance and one indicating improved cognitive performance. Following 30 min of active video game play, participants showed improved performance on measures of decision making and problem solving. In particular, a small effect was shown on Block 3, and a marginal effect was seen on Block 4 of the IGT. No gender differences were seen in performance on these blocks, but there was a marginal gender difference during Block 2 (part of the decision making under ambiguity trials; Brand, Recknor, et al., 2007). During Blocks 3 and 4 on the IGT, participants should have become familiar with the risks and benefits of each deck, learning which decks are advantageous and which are disadvantageous. In other words, decision making under ambiguity should be transitioning to decision making under risk (Brand, Recknor, et al., 2007), and participants should begin selecting from Decks C and D rather than Decks A and B. In some cases, participants fail to learn to choose advantageously, or need more time to learn these probabilities (Buelow & Suhr, 2009; Buelow et al., 2013). In the present study, participants were quicker to shift to the advantageous decks following 30 min of active video game play. It is possible that playing video games requires participants to quickly learn and adapt to changing environments, which in turn would prime them to more quickly learn the risks and benefits of each deck on the IGT. However, on Block 5, performance was equivalent across video game groups, indicating that the control group "caught up" to the video game group. This finding is counter to Bailey et al. (2013); however, they did not have participants actively play video games prior to administration of the IGT.

No between-group differences were found on the BART, which assesses risk-taking and decision making processes. This lack of group differences is counter to previous research that has found increased risky cognitions following active video game play (Fischer et al., 2007). The contrary findings between the IGT and BART are not unexpected, as multiple previous studies have shown that the IGT assesses risky decision making but the BART assesses risk-taking behavior more generally (Aklin et al., 2005; Buelow &

Blaine, in press; Lejuez et al., 2003; Upton, Bishara, Ahn, & Stout, 2011). Thus, it may be that video game play enables individuals to adapt to situations sooner and make better decisions, but does not increase their propensity to engage in behavioral risk-taking. In addition, our participants played one of multiple games that varied on several factors, ruling out a game-type effect that may be present in other studies that only use a single game or single game type. Given that both decision making and risk-taking have not frequently been examined with behavioral measures such as the IGT and BART in the video game literature, additional research is needed to further tease apart the relationship between these variables.

Lastly, we found a significant improvement in problem solving, both in terms of the number of categories completed and the total number of errors on the WCST, as a function of active video game play. No prior studies have examined performance on this task as a function of video game history or active video game play; however, the results are consistent with previous research showing improved performance on measures of executive functions following video game play (Basak et al., 2008; Boot et al., 2008; Maillot et al., 2012; Mathews et al., 2005; Stern et al., 2011). In addition, these results are consistent with neuroimaging studies showing increased gray matter in the dorsolateral prefrontal cortex, an area associated with problem solving and the WCST (Colom et al., 2012; Kuhn et al., 2014). It is likely that during video game play, participants must learn to adapt to a ever-changing environments and learn the most optimal way to complete a level. This process often requires trial-and-error learning, the same skills required to perform well on the WCST and IGT. It is possible that actively playing video games serves as a priming for subsequent tasks, with skills learned during the game (such as quick and efficient decision making and problem solving) transferred to later occurring tasks. Thus, participants may be more likely to attend to patterns on the IGT and WCST after this procedural mindset has been activated in a preceding task. Procedural mindset priming has been shown to occur in other domains (see Forster, Friedman, & Liberman, 2004; Gollwitzer & Kinney, 1989; Smith & Branscombe, 1988; for examples). This priming effect may be short-lived (see Van den Bussche, Van den Noortgate, & Reynolds, 2009, for discussion of priming effects), but additional research is needed to examine how long these priming effects may last after active video game play.

A final exploratory aim of the present study was to examine gender-based differences in the effects of active video game play on cognition. Many of the previous studies of video game play effects on cognition were conducted on male participants only, with results showing both improvements (Blacker & Curby, 2013; Boot et al., 2008; Colzato et al., 2013; Donohue et al., 2010; Green & Bavelier, 2006) and no difference (Bailey et al., 2010; Collins & Freeman, 2014; Wilms et al., 2013) compared to control groups. In the present study, gender did not emerge as a significant predictor of performance, nor were any of the group by gender interactions significant. This lack of gender differences occurred despite differences in self-reported previous video game exposure. Among participants in the video game group, 100% of females reported previously playing video games but only 26% self-identified as a “gamer.” Among males, 100% reported a history of video game play and 66% self-identified as a “gamer.” In addition, it is unlikely that previous familiarity with the game played affected the results. Only 32% of video game participants reported having previously played the study game, and this was distributed evenly across the five game conditions, $\chi^2(4, N = 91) = 7.893, p = .096$.

In addition, assessing cognition following active video game play, rather than assessing self-reported history of video game play and then assessing cognition, could indicate a direct effect of game play on attentional and other cognitive changes. Further, our study utilized five different video games, indicating that the cognitive

improvements seen were not a direct result of a unique feature of a single game but rather play components present across games.

4.1. Limitations

There were several limitations in the present study. Although no gender differences emerged in the current study, a greater proportion of males self-identified as “gamers.” It would be important to follow-up on the present study with a sample of female gamers, to determine if the cognitive benefits seen here are due in part to frequency of video game play. Not all executive functions were assessed in the present study, and it is possible that different findings would be seen if other executive tasks—or measures of a particular executive function such as decision making—were utilized. Participants in the present study who were in the video game condition played one of five games for 30 min immediately prior to cognitive assessment. Given some of the previous research regarding longer-term effects of video game play or training (e.g., Colom et al., 2012; Kuhn et al., 2014), future research should investigate whether there is an optimal amount of video game exposure before cognitive improvements taper off or even diminish.

4.2. Conclusions

Taken together, the results of the present study are more consistent with the hypothesis that active video game play can improve cognition, rather than the hypothesis that active video game play results in impairments in cognition. It is likely that the effects of video game play on cognition are more complex than a simple dichotomous good/bad distinction, as it could be the amount of game play and the expertise (i.e., gamer versus nongamer) of the player may influence this relationship. It is also possible that video game play improves some facets of cognition (such as executive functions) but decreases some other aspects of cognition.

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