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What would my avatar do? Video games and risky decision making

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What would my avatar do? Video games and risky decision making

by

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ABSTRACT

Several decades of research have established that video game experience is associated with differences in social information processing, visual-spatial processing, and cognitive control. Fewer studies have examined the relationship between video game experience and risky decision making outside of the gaming environment. The current set of studies examined the hypothesis that video game experience is associated with riskier decision making due to differential sensitivity to outcomes (i.e., reward, punishment). Study 1 was designed to explore the relationships between video game experience, risky decision making, and sensitivity to outcomes in a large sample of individuals. Study 2 was designed to investigate the association between individual differences in video game experience and the neural correlates of outcome sensitivity. Finally, Study 3 was designed to establish a causal relationship between immediate, brief experience with a video game and sensitivity to outcomes. The findings from the three studies indicate that video game experience is associated with differences in outcome sensitivity, but the relationship is complex and may depend on various factors, such as the genre of the video game and the presence of symptoms of pathological use. The data from the current set of studies should serve as a starting point for further research examining video games and risky decision making.

CHAPTER 1. GENERAL INTRODUCTION

Computer and video games represent one of the most pervasive forms of leisure activity in modern culture, being played in 72% of American households (Entertainment Software Association (ESA), 2012). A little more than half of video game players are male (58%), and male dominated genres of video games (e.g., action, sports, and shooter) make up over 50% of the annual sales in video games (The NDP Group, 2010). While the average gamer is between the age of 18 to 49 years (ESA, 2012), approximately 88% of individuals' ages 8 to 18 years report that they occasionally play video games and 23% report playing video games at least once per day (Gentile, 2009).

Considering the prevalence of video game consumption in society, it is important to understand the impact of this medium on video game players. The scientific literature on video game effects has examined a number of affective and cognitive processes to date. For instance, the data provide ample evidence that some genres of video games increase aggression (Anderson, Gentile, & Buckley, 2007; Anderson et al., 2010; Sestir & Bartholow, 2010; Bartholow, Sestir, & Davis, 2005), benefit visual-spatial processing (Green, Li, & Bavelier, 2009; Li, Polat, Makous, & Bavelier, 2009), and produce various (usually negative) effects on executive functioning (Bailey, West, & Anderson, 2010; Mathews et al., 2005) and affective processing (Bailey, West, & Anderson, 2011; Kirsh & Mounts, 2007). These latter effects are particularly relevant given the impact of executive functioning and affective processing on the quality of decision making (Figner & Weber, 2011;

Weber & Johnson, 2009; Metcalfe & Mischel, 1999), suggesting there is reason to believe that video game use may be related to changes in decision making.

Decision making is a crucial part of successfully achieving one's goals in many scenarios, including those encountered in video games. The goals that are faced in a video game are not typically realistic and the actions required to achieve these goals in game may be detrimental if replicated outside of the video game environment (e.g., stealing a car to get to a job, shooting other players to make money). Because the goals of a video game are limited in scope, the strategies useful for completing those goals may also be limited. For example, to accomplish the main objectives in a typical first-person shooter video game (e.g., *Call of Duty*, *Medal of Honor*), rushing through the level engaging and terminating enemies as you encounter them is a more effective strategy than attempting to carefully maneuver through the environment to circumvent the opponents. Killing enemies often provides bonuses (e.g., points, money, weapon upgrades) and there is usually no benefit to avoiding encounters. In this way, video games may reward frequent use of a limited behavioral repertoire.

Video games do frequently reward risky and impulsive behavior (Gentile & Gentile, 2008; Anderson & Carnagey, 2009), but the relationship between video games and decision-making has received relatively little attention even though it has the potential to impact the real-world behavior of video game players (Gentile & Gentile; Beullens, Roe, & Van den Bulck, 2011). In a recent meta-analysis of media effects on risk-taking, only six out of more than 80 studies examined the relationship between video games and risk-taking (Fischer, Greitemeyer, Kastenmuller, Vogrincic, & Sauer, 2011). The findings indicated that racing video games increased risky driving behavior in the real world; however, this leaves open the question of how other genres of video games may be related to risky decision making.

Genre is used to informally classify video games for marketing and research purposes (ESA, 2012). Classification within a genre is based largely upon the mechanics of game-play or how the player goes about completing the goals in the game (Lewis, McGuire, & Fox, 2007; Wolfe, 2000). Action video games are characterized by their fast-pace and continual updating of visual information. These games typically require players to locate and interact with targets in a complex visual scene (Green et al., 2009). Action video games need not contain violence (as for instance in *Portal: Still Alive*), but they frequently do (as in *Unreal Tournament*, *Grand Theft Auto*, *Call of Duty*). First-person shooters (FPS) may be considered a sub-category of action games. Action video games can be contrasted with the broad category of non-action video games, which may include several genres, such as strategy, racing, simulation, and puzzle. These genres may differ from action video games and each other in terms of visual complexity, speed of information processing, and violent content (Adams, 2010). Strategy video games, for instance, typically rely on deliberate planning of actions rather than quick reactions to events in the game (Wolf, 2000).

There is some evidence to suggest that various genres of video games can produce differential effects on behavior. For example, action video games are negatively associated with executive function (Bailey et al., 2010; Mathews et al., 2005), while strategy video games may improve executive processes (Basak, Boot, Voss, & Kramer, 2008). Furthermore, non-action video games typically used as controls (e.g., *Tetris*) may in fact modify performance on tasks believed to only be influenced by action games (Bailey & West, 2012). The purpose of the current set of studies was to examine how exposure to video games is related to risky decision making. The goal of Study 1 was to explore the relationship between screen time, genre, pathological video game use (Gentile, 2009), and behavior on risky decision making tasks. To examine the effects of game genre, participants were classified as action (e.g., *Unreal Tournament*, *Call of Duty*), strategy (e.g., *Starcraft*, *Rise of Nations*), or simulation (e.g., *Rock Band*, *The Sims*) gamers, based on the video games they most frequently played. The goal of Study 2 was to investigate the association between individual differences in exposure to action video games, specifically first-person shooters, and the neural correlates of risky choices and sensitivity to feedback. The goal of Study 3 was to determine if short-term exposure to first-person shooters, racing, and puzzle video games primes differences in risky decision making.

The remainder of the general introduction provides a brief overview of the video game literature, with particular attention to the research related to risk taking and pathological video game use, followed by an overview of the decision making literature related to risk and reinforcement learning. Finally, the goals of the current set of studies are described more fully before proceeding to the data for Study 1.

Video Games

From their inception, video games have garnered a great deal of attention from researchers due to their widespread use and because they immerse individuals in imaginary worlds, engaging in behaviors that may transcend game play to the natural environment (Anderson et al., 2010; Anderson, 2004; ESA, 2012). Research over the last few decades has demonstrated that video games influence a wide range of processes, from aggressive thoughts and behavior (Anderson & Carnagey, 2009; Anderson et al., 2008) to the temporal and spatial components of vision (Green & Bavelier, 2003; Green et al., 2009) to cognitive control (Bailey et al., 2010; Basak et al., 2008). The following section provides an overview of the primary areas of research on the effects of video games. I begin with the topic that has received the most attention (i.e., aggression and affective processing) and then proceed through the other areas in descending order of the amount of research that has been done. The last sub-sections address the limited amount of research that has been done in the areas of risk-taking and pathological gaming, which are the most relevant to the current studies.

Mortal Kombat: Violent Video Games and Social Information Processing

Numerous studies have demonstrated the deleterious effects of violent video games on social information processing (Anderson et al., 2010). Long-term exposure to video games with violent content is associated with increased aggressive thoughts, feelings, and behaviors, and these effects have been demonstrated following short-term exposure to video games in the laboratory (Anderson et al., 2010; Anderson et al., 2007). Desensitization to violence immediately following exposure to video game violence has been demonstrated at the behavioral level as a decrease in the likelihood that players will notice and help a victim of violence (Bushman & Anderson, 2009) and at the physiological level as less change in heart rate and a lower skin conductance response to violent images (Carnagey, Anderson, & Bushman, 2007). Additionally, individual differences in exposure to video game violence has been associated with attenuated amplitude of components of the event-related brain potentials (ERPs) when viewing violent, but not other negative, pictures (Bailey et al., 2011; Bartholow, Bushman, & Sestir, 2006). Recent studies have also established a causal link between video game violence and decreased prosocial behavior (Anderson et al., 2010; Sestir & Bartholow, 2010; Bushman & Anderson, 2009). Finally, Kirsh and colleagues (Kirsh & Mounts, 2007; Kirsh, Mounts, & Olczak, 2006) have demonstrated that individuals with exposure (long-term and acute) to violent media are slower to identify neutral faces morphing to a happy expression and faster to identify neutral faces morphing to an angry expression, indicating they may be less sensitive to positive affect and have heightened sensitivity to negative affect. Taken together, these findings suggest that violent video games affect antisocial (e.g., aggression, desensitization), and prosocial (e.g., sensitivity to positive emotion, helping behavior) variables.

How to Train Your Brain: Video Games and Visual-spatial Processing

A number of studies have demonstrated that experience with action video games has beneficial effects on visuospatial processing, ranging from visual acuity (Green & Bavelier, 2007) to visual search and object tracking (Green & Bavelier, 2006). Positive correlations have been found between video game play and hand-eye coordination (Griffith, Voloschin, Gibb, & Bailey, 1983), the efficiency of visual search (Castel, Pratt, & Drummond, 2005), and tracking in a flight simulator (Lintern & Kennedy, 1984). Additionally, research has demonstrated that performance on many of these tasks can be improved by training on action video games (Dye, Green, & Bavalier, 2009; Green & Bavelier, 2007; Feng, Spence, & Pratt, 2007; Green & Bavelier, 2003; Greenfield, DeWinstanley, Kilpatrick, & Kaye, 1994; Dorval & Pepin, 1986). The basis of all of these effects appears to be an improvement in the integration of information as a result of more efficient use of sensory information by action gamers (Green, Pouget, & Bavelier, 2010).

The useful field of view task (UFOV; Edwards, Vance, Wadley, Cissell, Roenker, & Ball, 2005) represents one example of a measure used to test for individual differences in action video game experience and the effects of training on the spatial distribution of visual attention. The useful field of view is the area of the visual world from which information can be extracted without eye or head movements, and is particularly relevant in the context of training as performance on UFOV predicts driving performance in older adults (Clay, Wadley, Edwards, Roth, Roenker, & Ball, 2005). In this task, participants must identify the location of a target on the screen among distractors. Multiple studies have demonstrated improvements on the UFOV task after only 10 hours of action video game training compared to 10 hours of training on a non-action video game (Green & Bavelier, 2006; Green & Bavelier, 2003) and this effect has been found to last for at least five months after training (Feng et al., 2007). In Studies 1 and 2 of the current paper, the UFOV task was used to verify that the self-reported action gamers were similar to the samples in previous individual difference studies and to examine whether other genres of video games were associated with differences in the UFOV. This task was chosen in particular because of its reliability and validity as a predictor of real-world behavior (Clay et al.; Myers, Ball, Kalina, Roth, & Goode, 2000)

Knockout: The Effects of Gaming on Executive Function

The effect of experience with action and violent video games on executive functions has been examined with various measures including the Stroop task (Bailey et al., 2010; Mathews et al., 2005), task switching paradigms (Boot, Kramer, Simons, Fabiani, & Gratton, 2008; Karle, Watter, & Shedden, 2010; Strobach, Frensch, & Schubert, 2010), and the N-back task (Basak et al., 2008; Boot et al., 2008). Video game experience has been associated with increased interference in the Stroop task (Kronenberger et al., 2005) and the under recruitment of a brain network including the anterior cingulate cortex (ACC) and lateral prefrontal cortex (LPFC) that supports cognitive control (Mathews et al., 2005).

Cognitive control, which allows one to maintain goal-directed information processing, can be divided broadly into proactive and reactive processes. Proactive processes maintain optimal information processing over time through moment-to-moment adjustments of control settings, whereas reactive processes resolve conflict when competing responses are activated within a trial (Braver, Gray, & Burgess, 2007). Bailey et al. (2010) found that action video game experience was associated with a reduction in proactive control and had little or no relationship with reactive control. The negative association between game experience and cognitive control is of particular concern because screen time can be relatively high during late childhood and adolescence, an important period for the development of executive functions (Diamond & Amso, 2008). In addition, similar neural structures are involved in cognitive control and decision making (Steinberg, 2008; Christopoulos, Tobler, Bossaerts, Dolan, & Schultz, 2009), so the effects of exposure to video games on these brain areas may have negative consequences for the efficacy of decision making as well.

Need for Speed: Racing Video Games and Risk-Taking

The existing research examining video games and risky decision making has focused mainly on the effects of racing video games on attitudes towards and engagement in risky driving behaviors (e.g., speeding, fun riding, street racing; see Fischer et al., 2011). The data indicate that exposure to racing games is associated with increased positive attitudes towards risk-taking (Fischer, Kubitzki, Guter, & Frey, 2007), self-perception as a risky driver (Fischer et al., 2009), and the likelihood of risky driving among adolescents and adults, particularly males (Beullens et al., 2011). Additionally, racing video games appear to be most attractive to individuals who already have an increased risk of car-related accidents and deaths (National Highway Traffic Safety Administration, 2009).

Fischer et al. (2007, Study 1) surveyed 290 men and women on their driving behaviors and experience with several popular racing video games. They found that playing racing video games was positively correlated with self-reported competitive driving behavior ($r = .49$) and the need to show impressive road traffic behavior ($r = .43$), two indicators of risk-taking on the road. Furthermore, racing video game experience was negatively correlated with cautious road traffic behavior ($r = -.21$). Similarly, Beullens, Roe, and Van den Bulck (2008) found that among a large sample of adolescents, playing racing video games significantly predicted more positive attitudes towards fun riding (i.e., viewing driving as entertainment and thus engaged in riskier driving behaviors to increase the enjoyment), which was a significant predictor of intentions to engage in fun riding behavior. In a longitudinal study of attitudes towards risk-taking and real-world driving behavior, Beullens et al. (2011) found that having a history of playing racing video games significantly predicted greater prevalence of speeding two years later. This evidence supports the hypothesis that racing video games negatively impact attitudes towards and engagement in safe driving behavior.

To establish that the relationship demonstrated in the previous studies was causal, researchers have also attempted to prime risky attitudes and behaviors towards driving by having participants spend as little as 20 minutes playing a racing video game. In Study 2 of Fischer et al. (2007), participants played either a racing video game or a neutral game for 20 minutes and then responded to questions that assessed the accessibility of risk-related cognition as well as levels of excitement and arousal. Participants who played a racing game had greater accessibility of risk-related thoughts and reported greater levels of excitement and arousal. Study 3 by these investigators replicated the increase in risk-promoting thoughts and demonstrated that participants who played a racing video game were more likely to engage in risky driving behaviors (Fischer et al., 2007). In this study, the Vienna Risk-taking Test (Schuhfried, 2006) was used to assess actual risky driving behaviors. In the test, participants view a real-life video of a risky driving technique and press a key to indicate when they would choose to abort the maneuver.

Participants who had just played a racing game had longer reaction times, indicating greater risk-taking.

A similar set of experiments demonstrated that increases in the accessibility of risk-promoting thoughts and in actual risky driving behaviors following exposure to racing games is mediated by the individual's perception of themself as a reckless driver (Fischer et al., 2009). Risky driving behavior was greater in men than women and when the participant was the player rather than the observer of a racing game. Importantly, increased risk-related thoughts and behaviors due to increased perception as a reckless driver were only found in participants who played a racing game that rewarded traffic violations. Playing a racing game that did not reward risky-driving behavior did not produce this effect (Fischer et al., 2009).

Racing video games prime risk-related thoughts and risky driving behaviors, but it is as yet unclear whether different genres of video games can also prime risky decision making in other domains. Action video games have been associated with reliance on reactive rather than proactive cognitive control in the Stroop task, suggesting that action gamers tend to make their responses more in the moment rather than pre-planning their actions (Bailey et al., 2010). If this pattern extends to decision making in domains with serious consequences for the individual (e.g., gambling, substance use, social interactions), then it could be detrimental to their ability to avoid options that seem more appealing now, but have greater risks in the long-term. Therefore, one goal of the current study was to determine how action, strategy, and simulation video games are related to decision making under risk and uncertainty.

Mass Effect: Pathological Gaming and Attention

Recent work has revealed that between 8% and 9% of children and adolescent video game players meet criteria for pathological video game use (Gentile, 2009; Gentile et al., 2011). Pathological gamers play video games more frequently and for longer periods of time, skip other activities (e.g., homework, chores) to play video games, and report using video games to escape their problems more often than their peers. Several negative outcomes are associated with pathological video game use, including increased aggression, poor performance in school, elevated levels of depressive symptoms, and increased anxiety (Gentile et al., 2011). The relationship between pathological video game use and disorders of attention has been a topic of much speculation, but a relatively small body of literature has examined this association (Gentile et al., 2011; Swing, Gentile, Anderson, & Walsh, 2010; Gentile, 2009; Bioulac, Arfi, & Bouvard, 2008).

In the last decade, the United States has seen an increase in the number of children ages 4 to 17 years that are diagnosed with ADHD. In 2007, 9.5% of school-age children were diagnosed with ADHD, reflecting a 22% increase in the number of cases from 2003 to 2007 (Center for Disease Control, 2010). While children and adolescents with ADHD frequently find it difficult to perform tasks that require sustained attention, they will spend hours watching television, surfing the Internet, and playing video games (Yoo et al., 2004; Weiss & Weiss, 2002). Studies have shown that ADHD is associated with an increased likelihood of developing substance abuse during adolescence (Tapert, Baratta, Abrantes, & Brown, 2002; Biederman, Wilens, Mick, Faraone, & Spencer, 1998; Wilens, Biederman, & Mick, 1998), and this may extend to behavioral addictions as well (Davis, 2001). For example, Internet addiction in 10 to 12 year olds is associated with a greater number of ADHD symptoms related to impulsivity and inattentiveness and children diagnosed with ADHD are more likely to display symptoms of Internet addiction (Yoo et al., 2004). Children with ADHD spend more of their time online playing games than on other online activities (e.g., shopping, reading, posting; Yoo et al.), a finding that may provide a link between Internet addiction and pathological video game use.

A few studies have explored the relationship between the amount of time spent playing video games and the number of ADHD symptoms. In a sample of 9th and 10th graders, Chan and Rabinowitz (2006) found that playing console or internet video games for more than one hour a day was positively correlated with scores on the inattention and ADHD subscales of the Connor's Parent Rating scale. Similarly, in a sample of 6 to 16 year olds, 34% of children diagnosed with ADHD endorsed five or more statements on a Problem Video Game Playing (PVP) survey modeled after the DSM-IV criteria for pathological gambling and substance abuse, whereas none of the control children endorsed more than four statements (Bioulac et al., 2008). These children had more severe symptoms of ADHD compared to children with the disorder who did not score over four on the PVP. While there were no differences in the number of hours ADHD and control children spent playing video games, parent reports revealed that hyperactive children were less likely to stop playing on their own and they responded to requests to stop playing with more negative behavior (e.g., arguing, whining, crying) than the control children. Children diagnosed with ADHD are at a greater risk for problematic video game playing and exacerbation of their attention problems.

Recent work has shed light on the negative outcomes that may be associated with pathological video game use (Gentile, 2009, Gentile et al., 2011; Pawlikowski & Brand, 2011). In a large sample of 8 to 18 year olds, 8.5% of participants met criteria for pathological video game use (Gentile, 2009). Pathological gamers were twice as likely to be diagnosed with an attention deficit disorder. Similar results were reported in a longitudinal study of children and adolescents from Singapore, where again approximately 9% met criteria for pathological video game use (Gentile et al., 2011). Children who started out as pathological video game users and remained that way for the duration of the study reported more symptoms of ADHD than their peers who never met criteria for pathological video game use. The longitudinal design of the study allowed the researchers to investigate risk factors and outcomes of pathological gaming. Impulsivity represented one risk factor for pathological gaming at the beginning of the study and predicted increases in pathological gaming over time. Pathological game use also predicted greater impulsivity (Gentile, Swing, Lim, & Khoo, 2012; Gentile et al., 2009; Swing et al., 2010), suggesting that there may be a reciprocal relationship between these variables.

Pawlikowski and Brand (2011) examined individual differences in excessive Internet gaming and performance on the Game of Dice task, a measure of risky decision making. In this task, the participant is instructed to make as much money as they could by guessing what number would come up when they rolled a 6-sided die over 18 trials. Each trial started with the participant selecting an alternative that had a fixed probability (i.e., 1:6, 2:6, 3:6, or 4:6) and a fixed monetary value. Low probability options were associated with greater monetary value. Excessive Internet gamers selected low probability options more frequently than non-gamers, resulting in greater losses, displaying similar behavior as individuals with other impulse control disorders. The emerging pattern from the literature suggests that pathological gamers tend to be more impulsive and take more risks than their non-pathological peers. Given these findings, one goal of Study 1 was to examine how pathological gaming was related to risky decision making.

Decision Making

Among the plethora of decisions facing an individual each day, many entail potentially risky outcomes, the probability of which the individual may or may not explicitly know. In the rational model of decision making behavior, individuals choose the option with the greatest amount of expected utility, regardless of any other considerations; however, human beings very rarely make decisions in this way, and their decisions are in fact influenced by a multitude of factors (Metcalfe & Mischel, 1999; Camerer & Weber, 1992; Weber, Blais, & Betz, 2002; Tversky, Slovic, & Kahneman, 1990; Tversky & Kahneman, 1974). Kahneman and Tversky's (1979) Prospect Theory (PT) describes actual decision making behavior when there is some risk or uncertainty about the outcomes. The main features of PT are 1) that the value function for possible outcomes is concave for gains, convex for losses, and steeper for losses than gains, and 2) small probabilities are over-weighted while medium and high probabilities are under-weighted (Kahneman & Tversky, 1992;

Kahneman & Tversky, 1979). In PT, humans do not always make the most rational decisions for a variety of reasons, which research has illuminated.

In the decision making literature, risk refers to situations where the mathematical probabilities of the different possible outcomes are known by the individual; uncertainty refers to situations where the mathematical probabilities of the outcomes are unknown (Weber & Johnson, 2009). Generally speaking, decision makers are adverse to both risk and uncertainty (Camerer & Weber, 1992; Kahneman & Tversky, 1992, 1984), but there are situational and individual difference variables that influence the extent of the aversion (Metcalfe & Mischel, 1999; Nosic & Weber, 2007). Similar factors influence decision making under uncertainty and under risk. The following sections describe research demonstrating the influence of situational variables on risky decision making, explore studies examining individual differences in risky decision making, and discuss work providing evidence for the neural processes underlying risky decision making and uncertainty.

Situational Factors that Influence Risky Decision Making

Research has revealed a number of situational variables that are associated with differences in risk aversion (Nosic & Weber, 2007; Read & Loewenstein, 1999; Tversky et al., 1990). For instance, research has demonstrated that framing a decision in terms of losses or gains produces different patterns of choices (Tversky et al., 1990; Kahneman & Tversky, 1984). When the choices are framed as gains, individuals are risk adverse; they will always choose a sure bet over a gamble. When the choices are framed as losses, individuals are more likely to take the gamble, becoming risk seeking (Kahneman & Tversky, 1992; Tversky & Kahneman, 1986). In other words, an individual faced with a decision may appear either risk adverse or risk seeking depending on the wording of the options.

Another situational variable that can influence the extent to which individuals are risk-averse is their current affective state (Weber, 2006; Read & Loewenstein, 1999; Metcalfe & Mischel, 1999). Dual process models of decision making propose that decisions are influenced by a “cold” analytical system that enables planning, cognitive control, and regulation of behavior, and a “hot” experiential system that relies on past experience and emotional reaction or “gut” feeling (Weber & Johnson, 2009; Stanovich & West, 1998; Kahneman, 2003). Both systems are usually at work in all of our decisions, but one system may more strongly influence decision making than the other (Weber & Johnson, 2009). “Hot” states result in greater risk taking than “cold” states, such that an individual may appear to be inconsistent in their risk-preference or even as an irresponsible thrill-seeker (Figner & Weber, 2011).

Domain and expertise are two other factors that account for some of the differences in preference for risk (Figner & Weber, 2011; Weber & Johnson, 2009). Research has found that risk taking in one domain was not necessarily a good predictor of risk taking in a different domain (Weber & Johnson, 2009; Nosic & Weber, 2007; Weber et al., 2002). Individuals have different appetites for risk depending on what they are making a decision about (e.g., social, financial, recreational). Individuals typically take more risks when they believe they are an expert in the domain (Hanoch, Johnson, & Wilke, 2006; Weber et al., 2002; Figner &

Weber, 2011), possibly because familiarity lowers the perceived risk of the options (Weber, 2006; Weber et al., 2002; Camerer & Weber, 1992).

Taken together, the findings from these studies suggests that far from being a stable attribute, an individual's aversion to risk fluctuates systematically across a number of situational variables. Attitude towards risk is not a general frame of reference from which an individual evaluates all of their decisions, but rather is part of a process in which risk is weighed within the current context (Figner & Weber, 2011). Related to the current set of studies, it would be useful to determine if and when risk-taking in a video game transfers to risky decisions in other contexts (e.g., do racing video games only increase risky driving?).

Individual Differences and Risky Decision Making

Research has demonstrated that preference for risk varies based on individual differences such as sex (Byrnes, Miller, & Schafer, 1999), age (Figner, Mackinlay, Wilkening, & Weber, 2009), and substance (ab)use (Kim, Sohn, & Jeong, 2011; Mitchell, 1999). These individual differences may be useful predictors of future risky decision making, and, in some cases, may provide information about commonalities that underlie risky decision making in general. The association between individual difference variables and risk taking is particularly relevant to the current set of studies which were undertaken to establish whether or not video game experience was associated with differences in risky decision making.

Numerous studies have documented sex differences in risk attitudes and behavior (for review, see Byrnes et al., 1999). Men tend to have more positive attitudes towards risk and to engage in risky behaviors more frequently than women

(Hanoch et al., 2006; Weber et al., 2002). When sex and domain are considered together, the data indicate that women are more risk averse in finances and less risk averse in social situations than men (Figner & Weber, 2011). This would suggest that examining the interaction between situational and individual difference variables may offer a more complete picture of risky decision making.

Age is another individual difference that accounts for changes in risky decision making. Adolescence is frequently linked to engagement in risky behaviors, such as reckless driving, illegal substance use, and unprotected sex; consistent with these perceptions, teenagers and young adults do take risks in these areas more frequently than children and older adults (Center for Disease Control and Prevention, 2011). In contrast, age differences are often not found in research using traditional tasks that involve monetary risk (Byrne et al., 1999). An explanation for this discrepancy may lie in the interaction between age and affect. In a recent study, two versions of a monetary reward task were developed to examine if the interaction between affect and age was associated with differential decision making (Figner et al., 2009). In a “cold” version of the task, adolescents did not differ from adults. In the “hot” version of the task, adolescents made riskier decisions resulting in less monetary gain compared to the adults. These data indicate that the greater risk-taking seen in adolescence is likely a result of their inability to regulate their emotions causing them to engage in high risk behaviors in contexts that are emotionally charged (Figner et al.).

Substance use (e.g., cigarettes, alcohol, illicit drugs) has also been linked to differences in risky decision making (Kim et al., 2011; Kirby, Petry, & Bickel, 1999;

Mitchell, 1999). Substance use can impact decision making in various ways, including poor executive function, differential sensitivity to positive and negative outcomes, and greater impulsivity. For example, insensitivity to negative outcomes was demonstrated in a sample of alcohol dependent patients using the Iowa Gambling Task (IGT; Kim et al., 2011). In the IGT, participants select cards from four different decks; selection from two of the decks would result in a net gain, while selection from the other two decks would result in a net loss (Bechara, Damasio, Damasio, & Anderson, 1994). Participants must learn which decks are “good” or “bad” from experience, and so this task demonstrates decision making under uncertainty. Alcohol dependent patients performed worse on this task overall, taking longer to learn from negative outcomes (i.e., continued selecting cards from the “bad” decks longer than the controls; Kim et al.). The same study found that alcohol dependent patients also take more risks on a monetary gambling task. Study 1 utilized the IGT to determine if the same pattern of behavior would emerge in pathological gamers.

The effects of nicotine on impulsivity have been studied extensively using the temporal discounting task (e.g., Ohmura, Takahashi, & Kitamura, 2005; Mitchell, 1999). In temporal discounting, participants are offered a choice between two monetary rewards. They may choose a small reward that they can receive immediately or after a short delay or they can choose a large reward that they will not receive until a longer amount of time has passed (Loewenstein & Thaler, 1989; Read, 2004). Selecting the smaller, immediate reward can be interpreted as greater impulsivity. Cigarette smokers have consistently been found to be more impulsive on this task, selecting the small, immediate rewards more frequently than non-smokers (Reynolds, Richards, Horn, & Karraker, 2005; Mitchell, 1999). Additionally, the extent to which they discount delayed monetary gains has been correlated with their daily nicotine intake (Ohmura et al.; Reynolds et al.). These findings indicate that substance abuse is associated with impulsive selection of immediate rewards possibly as a result of weakened executive control over behavior. Participants in Study 1 performed the temporal discounting task to examine the relationship between pathological video game use and impulsivity.

Neural Correlates of Risky Decision Making

Brain areas involved in decision making can be roughly divided into two functional groups: deep brain structures, such as the limbic system and striatum, that are involved in acquiring the associations between stimuli as “good” or “bad” and invoking our primitive, affective responses to gains and losses; and higher brain structures in the frontal lobes that allow organization, planning, and control of our behavior in response to expected and unexpected outcomes (Bossaerts, Preuschoff, & Hsu, 2009; De Martino, Kumuran, Seymore, & Dolan, 2006; McClure, Ericson, Laibson, Loewenstein, & Cohen, 2007; McClure, Laibson, Loewenstein, & Cohen, 2004; Christopoulos et al., 2009; Tobler, O’Doherty, Dolan, & Wolfram, 2007). This pattern is found for decision making under risk as well as uncertainty (Hsu, Bhatt, Adolphs, Tranel, & Camerer, 2005; Huettel, Stowe, Gordon, Warner, & Platt, 2006).

Several lines of research have implicated the limbic system, striatum and cingulate cortex in risky decision making. The amygdala is typically involved in the initial affective response to a win or loss (De Martino et al., 2006). Striatal activity has been found to increase as the value of the options increases (Christopoulos et al., 2009), and activity in the ventral striatum has been correlated with the subjective value of the reward (Kable & Glimcher, 2007), suggesting the striatum may be involved in coding the value of the reward. Similar to the ventral striatum, activity in the posterior cingulate cortex has been correlated with the participants' subjective value of rewards more so than the objective amount of the reward, while activation in the anterior cingulate cortex has been associated with the amount of risk involved (Christopoulos et al., 2009). Dopamine release in the ventral striatum (Koepp et al., 1998) and activation in the nucleus accumbens and amygdala (Hoeft, Watson, Kesler, Bettinger, & Reiss, 2008) have been found when participants play a video game, suggesting similar neural networks support performance in gambling tasks and video games.

Activity in midbrain dopamine areas has been linked to processing outcomes in the temporal discounting task (McClure et al., 2004; McClure et al., 2007). Activity in the limbic and paralimbic systems was greater when the earlier reward was immediate (e.g., now versus 1 month), but not when both rewards were delayed (e.g., 1 day versus 1 month). When there was no immediate option available, the lateral prefrontal and parietal cortex were more active. Based upon the link between midbrain dopamine regions and video games (Koepp et al., 2008) and greater discounting in substance (ab)users (Mitchell, 1999), the temporal discounting task was used in Study 1 to examine the relationship between pathological gaming and preference for immediate versus delayed rewards.

Numerous studies have demonstrated the association between decision making and activity in regions of the frontal lobes. For example, activity in the inferior frontal gyrus has been associated with errors in predicting risk (d’Acremont, Lu, Li, Vander Linden, & Bechara, 2009) and decreases in activation in this region can predict the probability that the individual will select the risky option in a choice task. One interpretation of these data is that the inferior frontal gyrus may function as a marker for risk aversion or selection of the safer option (Christopoulos et al., 2009). Activity in the orbital-frontal cortex has also been found to decrease as participants display greater risk-seeking with losses (De Martino et al., 2006), therefore increased activation in these areas may indicate an increase in avoiding risk. Activity in the orbital-frontal cortex and the dorsolateral prefrontal cortex has been observed during video game play (Hoeft et al., 2008), providing further evidence that performance in gambling tasks and video games is supported by similar neural networks.

Lesion studies have indicated that damage to areas of the PFC disrupts learning in gambling tasks. In the Iowa Gambling Task (IGT), controls show anticipatory skin-conductance responses (SCRs) to selection from “bad” decks, while patients with damage to the ventromedial prefrontal cortex (vmPFC) do not (Bechara et al., 1996). The development of these anticipatory SCRs in healthy individuals occurs over the course of several selections from each deck. The authors propose that the vmPFC is involved in the process by which a neutral stimulus (e.g., deck of cards) becomes associated with “goodness” or “badness”, thus allowing the system to anticipate the outcome of a given behavior (e.g., selection from a deck). In another study, patients with left ventrolateral and orbital lesions were more risk-taking than controls (Floden, Alexander, Kubu, Katz, & Stuss, 2008), which the authors suggested was due to damage to these regions resulting in decreased sensitivity to negative outcomes.

Repetitive transcranial magnetic stimulation (rTMS) has also been used to demonstrate the involvement of the prefrontal cortex in risky decision making. Disruption of left lateral prefrontal cortex with rTMS was associated with selection of immediate rewards over delayed rewards in the temporal discounting task (Figner et al., 2010). In another study, participants performed the risk task while rTMS was used to disrupt activity in either the right or left dorsolateral prefrontal cortex (Knoch et al., 2006). In the risk task, participants were shown six boxes and instructed to select the color (i.e., pink or blue) of the box they believed had a winning token. The color with the smaller number of boxes (e.g., 5 pink and 1 blue) will have a lower chance of holding the winning token (e.g., 1/6 chance), but will be worth a greater number of points if correct. Participants have to decide on each trial whether to select the bigger, but riskier payoff or to play it safe. Disruption of the right, but not the left, dorsolateral prefrontal cortex increased the number of risky choices, suggesting that activity in the right prefrontal cortex may moderate the urge to take risks (Knoch et al.).

The risk-taking tendencies of adolescents provide an example of how higher cortical areas and more primitive subcortical structures interact to influence decision making. The developmental course of the underlying neural circuitry for decision making described above has been used to explain the increased risk-taking observed in adolescent behavior (Somerville, Jones, & Casey, 2010; Casey et al., 2010; Galvan et al., 2006). Specifically, studies of brain development consistently find that adolescents have heightened activity in subcortical brain structures (e.g., the amygdala and nucleus accumbens) than children or adults. This is accompanied by less activation in prefrontal cortices (see Steinberg, 2008 for a review). These findings indicate that during adolescence, brain areas involved in reward circuitry are maturing, but the regions responsible for cognitive control will continue developing for a few more years, leaving teenagers with the unfortunate combination of greater sensitivity to rewards and less ability to control their impulses. The imbalance between the neural circuitry of reward and that of cognitive control in adolescence underlines the importance of illuminating the effects of video games on decision making so that we can understand their influence on the development of these brain structures.

In summary, subcortical brain structures process the valuation of reward and risk and the affective responses associated with gains and losses (Bossaerts et al., 2009), information that will be relayed to the prefrontal cortex which can exert cognitive control in service of avoiding unnecessary risks (Christopoulos et al., 2009; Tobler et al., 2007). Depending on the interaction between the affective response to a stimulus and cognitive control, an individual may be risk averse in one situation and risk-seeking in another, and systematic variation in these brain areas can account for individual differences in decision making across groups.

The Feedback-Related Negativity

Reinforcement learning in risky decision making tasks has been examined using ERPs. The component most frequently associated with studies utilizing gambling tasks is the feedback-related negativity (FRN). The FRN is a negative deflection in the ERPs occurring between 200 and 300 ms after negative feedback is delivered, over the midline frontal-central region of the scalp (Eppinger, Kray, Mock, & Mecklinger, 2007; Holroyd, Hajcak, & Larsen, 2006; Holroyd & Coles, 2002; Gehring & Fencsik, 2001). The nature of the FRN is particularly relevant to Study 2, which examines the neural correlates of decision making in video game players and non-players using ERPs.

Gambling tasks are frequently utilized to study the relationship between the amplitude of the FRN and reinforcement learning. Several studies have consistently demonstrated that the FRN is more negative to feedback indicating a loss than to feedback indicating a win (Hewig et al., 2007; Hajcak, Moser, Holroyd, & Simons, 2005; Holroyd, Nieuwenhuis, Yeung, & Cohen, 2003). Less clear is how the FRN is influenced by the participant’s knowledge of the probability or their expectancy to win. One study found that when participants knew they were close to winning, the amplitude of the FRN to loss feedback was greater (Hewig et al., 2007). This may indicate that the FRN is sensitive to the probability of reinforcement, or at least the subjects’ perception of the probability they will win (Hewig et al., 2007). Holroyd et al. (2003) further demonstrated that when contingencies are manipulated so that participants come to expect a win, the amplitude of the FRN is greater for losses, but when the contingencies are designed to build expectation of a loss, the amplitude of the FRN is decreased for losses.

In contrast to Hewig et al. (2007) and Holroyd et al. (2003), Hajcak et al. (2005) fixed the feedback in a decision task, so that participants either expected to win or lose and found no difference in the amplitude of the FRN for expected and unexpected outcomes. Furthermore, Experiment 2 of the same study used a similar task as Holroyd et al. and still did not replicate previous findings. The conflicting results suggest that for expectancy to influence the FRN participants must have enough knowledge about the reward contingencies to form an expectancy, and if the expectancies are manipulated in the experiment it must be salient.

Gambling paradigms are also useful for investigating the effects of reward magnitude on the FRN. Studies demonstrating no difference in the amplitude of the FRN for small and large losses or for neutral outcomes and losses seem to indicate that the neural generators that produce the FRN evaluate outcomes in a binary fashion, good versus bad (Hajcak, Moser, Holroyd, & Simons, 2006; Holroyd et al., 2006). Other research indicates that the amplitude of the FRN is mediated by the relative value of the feedback (Holroyd, Larsen, & Cohen, 2004). Holroyd et al. (2004) created “even”, “win” and “lose” conditions in a forced-choice task in which participants selected one of three balloons to win points. In the “even” condition, one of the balloons contained a reward, another contained a loss, and the third balloon was empty. In the “win” condition, one balloon was empty, one balloon contained a small reward, and the last balloon contained a large reward. In the “lose” condition, one balloon was empty, one contained a small loss, and one contained a large loss.

The data revealed that the amplitude of the FRN for the empty balloon in the “win” condition was larger than that of the empty balloon in the lose condition (Holroyd et al., 2004). One explanation is that the empty balloon in the “win” condition was the worst possible outcome while in the lose condition an empty balloon was actually the best outcome, and the amplitude of the FRN may represent the weighting of good and bad outcomes based on the relative value of the feedback, not the objective value. There was no significant difference between the worst outcome and the middle feedback in any of the conditions, although worst and middle feedback both elicited larger FRNs than the best feedback (Holroyd et al.). In summary, these studies demonstrate that the amplitude of the FRN is greater for losses than wins (Hajcak et al., 2007), is greater for unexpected than expected outcomes (Holroyd et al., 2003), and is based on the weighting of good and bad outcomes relative to the other available options (Holroyd et al., 2004). Given this evidence, it appears that the FRN is an index of activity in neural generators involved in coding the “goodness” and “badness” of an event.

Overview of the Current Studies

The goal of the current studies was to determine how exposure to video games, pathological gaming, and video game genre are related to decision making, impulsivity, and sensitivity to feedback in decision making tasks. This goal was motivated by findings from the few studies examining how racing video games relate to attitudes towards risk and actual driving behavior (Beullens et al., 2011; Fischer et al., 2009; Beullens et al., 2008; Fischer et al., 2007), and by work demonstrating that similar subcortical reward systems are activated during video game play (Hoeft et al., 2008; Koepp et al., 1998) and decision making under risk (Christopoulos et al., 2009; Kable & Glimcher, 2007). In addition, video game experience has been associated with variation in the use of proactive cognitive control (Bailey et al., 2010; Mathews et al., 2005) and affective processing (Bailey et al., 2011; Bartholow et al., 2006), both of which may have implications for decision making. Based on these findings, one may reasonably hypothesize that exposure to video games may influence decision making outside of the gaming environment by altering reward processing. The current studies were designed to test this hypothesis by answering three related questions: 1) is there a relationship between video game experience and risky decision making (beyond racing video games and driving)?, 2) is video game experience associated with changes in the neural correlates of risky decision making?, and 3) can brief exposure to a video game alter risky decision making?

Study 1 was designed to answer the first question by exploring the relationship between variables related to video game experience (e.g., screen time, pathological use, genre) and variables related to decision making (e.g., impulsivity, sensitivity to feedback, attitudes towards risk). Study 1 expands on previous work with racing video games (Beullens et al., 2011; Fischer et al., 2009; Beullens et al., 2008; Fischer et al., 2007) by examining multiple genres of video games and attitudes towards risk in domains that are unrelated to the video game environment (e.g., what is the relationship between action video games and gambling?). While the design of Study 1 was not suitable for making strong causal statements regarding the direction of the relationship between video games and risky decision making, it allowed for the testing of a wide range of variables. This helped guide the selection of tasks for Studies 2 and 3 by demonstrating the pattern of associations between the independent and dependent variables.

Study 2 addressed the second question by examining the relationship between individual differences in exposure to action video games and the neural correlates of feedback sensitivity in tasks that require decision making under risk. Sensitivity to feedback (i.e., increased sensitivity to reward, decreased sensitivity to punishment) is one pathway through which the reinforcement contingencies utilized by video games may alter risky decision making. Study 2 was also designed to expand the generalizability of previous work that demonstrated a relationship between video game experience and sensitivity to positive and negative picture stimuli (Bailey et al., 2011; Bartholow et al., 2006).

Finally, the third question was addressed in Study 3, which was designed to determine whether brief exposure to an action or racing video game could prime risk-taking and alter one’s sensitivity to feedback. Unlike Studies 1 and 2 which could only establish the existence of a relationship between the variables of interest, Study 3 was designed to provide evidence of a causal relationship between exposure to specific genres of video games and changes in decision making under risk.

CHAPTER 2. STUDY 1

Past research has demonstrated that experience with action video games (e.g., first-person shooters) is associated with decreased deployment of proactive cognitive control (Bailey et al., 2010; Kronenberger et al., 2005; Mathews et al., 2005), differences in the experience and expression of positive and negative affect (Bailey et al., 2011; Kirsh & Mounts, 2007; Bartholow et al., 2006), and an increase in the number of ADHD symptoms, particularly among individuals who report more symptoms of pathological video game use (Gentile, 2009, Gentile et al., 2011; Pawlikowski & Brand, 2011). Affect and attention can influence decision making (Figner & Weber, 2011; Weber & Johnson, 2009; Metcalfe & Mischel, 1999), so it seems reasonable to hypothesize that exposure to action video games may have negative consequences for the efficacy of one's judgment and decision making. Previous research with racing video games provides some evidence demonstrating that exposure to specific video games does influence real-world behavior related to decision making, with racing video games being associated with more risky driving behaviors among adolescents and young adults (Beullens et al., 2011; Fischer et al., 2009).

Study 1 was designed to determine whether there were significant relationships between measures of experience with video games (i.e., number of hours played per week, genre of game played most often, and number of pathological gaming symptoms) and attitudes towards risky behavior, impulsivity, and performance on several decision making tasks. Due to the limited research on the effects of video games in the domain of decision making, Study 1 was exploratory and utilized a mix of subjective and objective measures. The arsenal of questionnaires and experimental tasks that measure impulsivity and decision making under risk and uncertainty are summarized in Table 2.1. The media usage questionnaire measured the average number of hours spent gaming per week and the most frequently played genre of video games. The pathological gaming scale was used to assess problem gaming. Risky decision making was measured by the risk-attitudes scale, the risk task, and the temporal discounting task. The probabilistic selection and Iowa Gambling tasks were used to assess decision making based on feedback (i.e., reinforcement learning). Impulsivity was measured with the Barrett Impulsivity Scale and the stop-signal task. Finally, the Useful Field of View task was used to demonstrate that the high action video game players in the current study were representative of the video game players in studies of visuospatial processing (Green & Bavelier, 2003, 2006, 2007; Feng et al., 2007).

Table 2.1. Dependent Variables Associated with Each Measure.

Measure	Variables	Abbreviation
Media Usage Questionnaire	Mean hours per week, Genre: Action, Strategy, Simulation	Hours, Action, Strat, Sim
Pathological Gaming Scale	Number of symptoms	PVP
Barratt Impulsivity Scale	Total summed score	BIS-11
Risk-attitudes Scale	Average score	RAS
Useful Field of View	Accuracy	UFOV
Iowa Gambling Task	Number of good tokens selected, number of bad tokens selected	IGT
Stop-Signal Task	Average stop signal delay, average stop signal reaction time	SSD, SSRT
Temporal Discounting	Percentage of trials in which the earlier option was selected	Discount
Probabilistic Selection Task	Percentage of test trials in which A was chosen/B was avoided	Select A, Avoid B
Risk Task	Percentage of low risk selections, final score	Low Risk, Risk Rotal

One goal of the current study was to examine whether or not video game genres would have differential effects on decision making under risk. Video games can be classified in a number of ways, and the industry currently markets games under approximately 15 different genres (ESA, 2012). The current study limits its scope to three genres including action, strategy, and simulation games. This was motivated in part by previous work suggesting that these genres may not have the same consequences for visuospatial, cognitive, or affective information processing (Green et al., 2009; Bailey, 2009; Bailey & West, 2011; Basak et al., 2008).

The characteristics common to these genres seemed likely to influence decision making in logical and predictable ways. In an action video game, the goals are provided by the game and the player is not required to endogenously maintain his attention; instead the game directs the player's attention toward relevant stimuli. Reinforcement is immediate and negative consequences for failures are often minor (Rogers, 2010; Thompson, Berbank-Green, Cusworth, 2007). These features seem likely to encourage greater risk-taking, decreased sensitivity to negative outcomes, and preference for immediate reinforcement. In contrast, strategy video games require careful planning of one's actions in order to achieve long-term goals, which can typically be achieved in a number of ways that are of the player's choosing (Wolf, 2000). Failures are likely to be salient because of the greater time invested in achieving a goal (i.e., gratification is delayed), the personal responsibility for the effectiveness of the strategy, and the greater likelihood for real social consequences (e.g., other players become angry). These features would be expected to encourage greater risk-aversion, increased sensitivity to negative feedback, and increased willingness to wait for larger rewards. Finally, simulation games frequently require planning and execution of motor sequences for multiple events over the course of a few minutes. Feedback can be immediate or delayed (e.g., feedback that you hit a note in *Rock Band* as you are playing versus the number of stars you receive at the end of the song) and goals can be set by the game, the player, or a combination of the two (e.g., reaching the top of a career in The Sims versus building your own city). The structure of a simulation game may encourage taking the middle ground between safe choices and high payoffs, with the possibility of toppling either way.

The data were analyzed using three complementary methods to determine the nature of the relationships among the independent and dependent variables. Zero-order correlations were examined first to determine the simple relationships among the variables. Linear regression analyses were then conducted for each of the dependent variables to model the relationships with the independent variables and their interactions. Finally, a canonical correlation analysis was conducted to assess the relationship between the independent and dependent variables by extracting linear combinations among the two sets with the highest correlations. Based on the work of Gentile and colleagues (Gentile, 2009; Gentile et al., 2011), some tentative hypotheses about the effects of video game experience on decision making and impulsivity can be made. The average number of hours spent playing action video games per week should predict greater endorsement of riskier decisions and impulsivity, whereas playing strategy and simulation video games may not be associated with risky decision making. The number of pathological symptoms reported should predict risky and impulsive decision making. Finally, high action gamers should be more accurate on the UFOV task than strategy, simulation, or non-gamers.

Method

Participants

Data were collected for 149 undergraduates (70 females) from Iowa State University ranging from 16 to 30 years of age. Due to an error in the software, data for the testing phase of the probabilistic selection task was lost for one participant. Informed consent was obtained from all participants and they received course credit for their participation. The study was approved by the Institutional Review Board.

Materials and Design

All questionnaires can be found in the Appendices.

Media Usage Questionnaire. The media usage questionnaire included three higher order questions. Two questions asked the individual to indicate the number of hours spent playing video games on a typical weekday (Question 1, Monday through Friday) or weekend (Question 2, Saturday and Sunday) for each of four time periods (6 am to noon, noon to 6 pm, 6 pm to midnight, and midnight to 6 am). The third question asked the participant to indicate how often s/he plays each of 12 different genres of video games and what video game they spent the most time playing. The dependent variables used were the total number of hours spent playing video games per week (0 – 168) and classification as an action (i.e., first-person shooter), strategy, or simulation video game player (0 or 1) based on the genre of the video game they reported playing most often. The internal reliability was high for the number of hours played (*coefficient* α = .85) and for the amount of experience with genres of video games (*coefficient* α = .87).

Pathological Gaming Scale. A revised version of the pathological video gaming scale (PVP; Gentile, 2009; Gentile et al., 2011) was composed of 13-items that were based on the DSM-IV criteria for gambling addiction. Participants responded to each question by selecting “yes”, “no”, “sometimes”, or “don’t know”. The dependent variable was the number of questions to which they responded “yes” (1 – 13). The internal reliability for the current sample was acceptable (*coefficient* α = .60).

Barratt Impulsiveness Scale. The Barratt Impulsiveness Scale Version 11 (BIS-11; Patton, Stanford, & Barratt, 1995) was used to measure general impulsivity. The BIS-11 is comprised of 30 statements (e.g., I change hobbies; I plan for job security) and for each statement participants selected among the following options: “Rarely/Never”, “Occasionally”, “Often”, or “Almost always/Always”. For scoring, responses were coded numerically from 1 (rarely/never) to 4 (almost always/always) and summed to obtain a total score (0 – 120). Higher scores indicate greater levels of impulsivity. The internal reliability of the BIS in the current sample was high (*coefficient* α = .75).

Risk-attitudes Scale. A modified version of the Risk-attitudes Scale (RAS; Weber et al., 2002) included 20 statements from the ethical, gambling, and recreational subscales of the original measure. Participants indicated how likely or unlikely they would be to engage in the behavior described in each statement on a scale from 1 (very unlikely) to 5 (very likely). The dependent variable was the average score across all items (1 – 5). Higher scores reflect more accepting attitudes towards risk. The internal reliability of the measure in the current sample was high (*coefficient* α = .76).

Useful Field of View. The UFOV (Edwards et al., 2005) was used to measure selective visual attention to verify that participants with greater video game experience were similar to samples in other studies (Feng et al., 2007; Green & Bavelier, 2003). Participants located a target (triangle inside of a circle) among distractors (squares) in a briefly flashed display. On each trial a fixation square appeared for 20 ms. Targets were presented 10º (25 or 30 ms), 20º (25 or 30 ms), or 30º (25 or 30 ms) away from fixation along one of eight radial arms. A mask for 20ms followed the target and then participants were shown eight arms and indicated which one the target occurred on using the number key pad (1,2,3,4,6,7,8,9). The dependent variable was the overall accuracy for all eccentricities (*coefficient* α = .88).

Iowa Gambling Task. In the IGT (Bechara et al., 1994) participants selected one of four tokens on each trial in order to earn points. Each token was associated with its own set of gains and losses. Participants were instructed to try to earn as many points as possible before the end of the task. The gain or loss for each token was predetermined for each of the 100 trials, such that selecting two of the tokens (circle or square) on most trials results in a net gain of points, while selecting the other two tokens (crystal or diamond) on most trials results in a net loss of points. The participants were not told which tokens were “good” and which were “bad”. After a token was selected, the participant was informed of the outcome (gain or loss) and the total number of points they had earned. The tokens remained on the screen until the participant made a selection. The feedback was displayed for 1500 ms, and the response keys were ‘i’ (circle), ‘r’ (crystal), ‘c’ (square), and ‘m’ (diamond). The dependent variable was the number of times “bad” tokens were selected in the final 20 trials.

Stop Signal Task. In the Stop Signal task (Verbruggen, Logan, & Stevens, 2008), participants pressed a key to indicate whether they saw a circle (‘/’) or square (‘z’) on the screen. Each trial began with a fixation cross (+) for 250 ms followed by the stimulus, which remained on the screen until a response was made or for 1250 ms if no response was detected. The interstimulus interval was 2000 ms regardless of reaction time. On 25% of trials an auditory stop signal followed onset of the stimulus with a variable stop signal delay (SSD). Participants were instructed to withhold their response on these trials. Initially, the SSD was set at 250 ms for all participants. The SSD was adjusted continuously during the task such that when a participant successfully inhibited a response the SSD was increased by 50 ms and when the participant was unsuccessful at inhibiting their response the SSD was decreased by 50 ms. Participants performed a practice block of 32 trials and three experimental blocks of 64 trials each. Participants had to wait 10 sec between each block. The dependent variables reported were the mean SSD and the stop-signal reaction time (SSRT). SSRT was obtained by subtracting the mean SSD from the mean RT.

Temporal Discounting. The temporal discounting task was similar to McClure, et al. (2004). Participants stated their preference in a series of choices between a smaller amount of money received at an earlier time and a larger amount of money received at a later time. Participants were instructed to make each decision as if they would receive the option they selected. The first two choices were fixed to allow participants to learn how to respond in the task. The first choice required participants to select between the same amounts of money available at two different delays (e.g. $27.10 in 2 weeks vs. $27.10 in 1 month and 2 weeks) and the second choice required participants to select between two amounts of money in which the earlier amount is less than 1 percent of the later amount (e.g. $0.16 today vs. $34.04 in 1 month and 2 weeks). The remaining 40 trials were constructed by combining one of the early delays (today, 2 weeks, or 1 month) with one of the later delays (2 weeks, 1 month) and one of the following percent differences in amount of money: 1%, 3%, 5%, 10%, 15%, 25%, 35%, 50%. The early amount of money was drawn randomly from a range of $5 to $40 and then the larger amount of money was set to the specified percent difference. All combinations of the early delays, late delays, and percent differences were used excluding those where the later delay would be more than 6 months after the experiment. The two options were displayed on either side of the screen with the smaller, earlier reward always presented on the left, and the options remained on the screen until a response was made. A yellow triangle located below each option turned red for 2000 ms after the response to indicate the selection. This was followed by a blank screen for 2000 ms and then the next choice appeared. Response keys were ‘v’ for the option on the left and ‘m’ for the option on the right. The dependent variable was the percentage of choices where the earlier/smaller amount of money was selected. Selecting the earlier option more frequently indicates greater risk aversion.

Probabilistic Selection. In the probabilistic selection task (Frank, Seeberger, & O'Reilly, 2004), participants viewed three pairs of stimuli (AB, CD, EF) presented randomly and were instructed to select one of the stimuli in each pair. Probabilistic feedback was presented after each selection. In the first pair, selecting A led to positive feedback (i.e., "Correct!") 80% of the time and selecting B led to negative feedback (i.e., "Incorrect") 20% of the time. In the second pair, selecting C led to positive feedback 70% of the time, and in the third pair selecting E led to positive feedback 60% of the time. Participants performed three learning blocks of 60 trials (20 of each pair). In the final block, participants viewed all possible pairs of the six stimuli four times each and received no feedback about their choices. The stimuli were six Japanese Hiragana characters counterbalanced across the three feedback probabilities (i.e., AB, CD, EF). In all blocks, the figures remained on the screen until a response was made or until 4000 ms passed if no response was detected. In the learning blocks, feedback was displayed for 1500 ms. There was a 500 ms response-to-stimulus interval in the final block. Response keys were 'v' to select the figure on the left and 'm' to select the figure on the right. The dependent variables were the percentage of trials where A was select and B was avoided (i.e., not selected) in the final block. Greater selection of A than avoidance of B in the final block indicates learning based on positive rather than negative outcomes. Greater avoidance of B than selection of A in the final block indicates learning based on negative outcomes more than positive outcomes.

Risk Task. In the risk task (Knoch et al., 2006), participants were presented with six boxes, each equally likely to contain a winning token. Some boxes were blue and others were pink. Participants were instructed to select the color of the box they believed to contain the winning token. If they chose correctly they received the number of points associated with the color they had selected, but if they were incorrect they lost that many points. Two variables were manipulated in this task. The level of risk refers to the ratio of pink and blue boxes which can be 5:1, 4:2, or 3:3. For example, if there are 5 blue boxes and 1 pink box, then there is a 1 in 6 chance that the pink box contains the winning token; therefore selecting pink would be riskier than selecting blue. The balance of reward refers to the number of points the colors are worth and can be 90:10, 80:20, 70:30, or 60:40. The color with fewer boxes was always worth the greater point value. In the example above, for instance, selecting pink would be worth 90 points while selecting blue would only be worth 10 points. Participants completed 100 trials. Four of these were combinations of the 3:3 level of risk with balance of reward and were not included in the analysis. The remaining 96 trials included all other possible combinations of level of risk, balance of reward, and color. The level of risk was displayed above the boxes on each trial and the balance of reward was displayed below. The box displays remained on the screen until the participant responded followed by feedback displaying the outcome and total points for 1500 ms. The response keys were ‘v’ to select pink and ‘m’ to select blue. The dependent variables for this measure were the total score at the end of the task and the percentage of low risk selections.

Procedure

All stimuli were presented using E-Prime 1.2 Software (Psychology Software Tools, Pittsburgh, PA) with the exception of the stop-signal task which was presented using the STOP-IT program (http://web.me.com/frederick.verbruggen/Site/STOP-IT.html). Participants signed the informed consent and completed the BIS-11, pathological gaming scale, Risk-attitudes scale, and the media usage questionnaire. Half of the participants completed the tasks in the following order: temporal discounting, risk task, Iowa Gambling Task, Stop-Signal Task, and Probabilistic Selection; the other half of the participants completed the tasks in the reverse order. After the tasks were completed the participants were debriefed and thanked for their participation. The entire study took approximately 90 to 120 minutes.

Table 2.2. Descriptive Statistics for All Independent and Dependent Variables.

	M	*SD*	Range
Hours	20.63	25.38	0-139
Action	--	--	0-1
Strat	--	--	0-1
Sim	--	--	0-1
PVP	1.84	1.98	0-8
BIS-11	65.48	8.93	46-90
RAS	2.17	.55	1.05-3.75
UFOV	.70	.25	.04-1.0
IGT	10.91	4.32	0-20
SSD	457.21	199.91	50-1043.8
SSRT	238.68	62.27	-64-569.6
Discount	.73	.21	0-1.0
Select A	.63	.21	0-1.0
Avoid B	.65	.24	.06-1.0
Low Risk	.83	.14	.30-1.0
Risk Total	318.52	698.51	-2360-1240

Results

Sample Characteristics. The purpose of Study 1 was to ascertain the nature of the relationships between the measures of video game experience and the dependent variables (see Table 2.2 for means, standard deviations, and ranges of all measured variables). More than half of the sample (64%) reported playing video games at least two hours per week. The average amount of time reported playing video games was 20.6 hours per week (*SD* = 25.4; *25th quartile* = 0, *50th quartile* = 13, *75th quartile* = 34). Males reported playing more hours per week (*M* = 28.2, *SD* = 21.89) than females (*M* = 12.1, *SD* = 26.5), *t*(147) = 4.06, *p* < .001. Pathological video game use (i.e., responding "yes" to 6 or more of the statements on the PVP scale) was reported by 7.4% (males = 13.9%, females = 0%) of the sample, consistent with percentages found in children and adolescents (Gentile, 2009; Gentile et al., 2011). The mean number of symptoms of pathological video game use reported in this sample was 1.8 (*SD* = 2). Males reported more symptoms of pathological video game use (*M* = 2.7, *SD* = 2.1) than females (*M* = .8, *SD* = 1.2), *t*(147) = 6.90, *p* < .001.

Zero-order Correlations. The interactions between the video game measures are potentially interesting, so seven two-way interaction terms were computed; the number of hours spent playing video games per week (hours) with PVP and each of three genres of video games (i.e., action, strategy, and simulation games), and PVP with the three genres. Correlations among all of the variables are shown in Table 2.3.

Table 2.3. Correlation Matrix with All Independent, Dependent, and Interaction Terms.

	Hours	Action	Strat	Sim	PVP	BIS-11	RAS	UFOV	IGT	SSD	SSRT	Discount	Select A	Avoid B	Low Risk	Risk Total	Hours*PVP	Hours*Action	Hours*Strat	Hours*Sim	PVP*Action	PVP*Strat
Action	.12																					
Strat	.05	**-.32**																				
Sim	-.11	**-.38**	**-.38**																			
PVP	**.55**	**.20**	**.24**	**-.19**																		
BIS-11	**.18**	.04	-.08	-.11	.13																	
RAS	.11	.16	-.06	-.08	.13	**.29**																
UFOV	.16	.07	.04	.10	**.28**	-.05	.06															
IGT	.15	-.01	.08	-.13	.07	-.09	-.10	-.06														
SSD	-.10	-.06	-.11	.13	-.10	-.05	-.05	-.04	.02													
SSRT	.04	.04	.03	-.10	.01	.04	.06	**-.18**	.02	**-.58**												
Discount	.10	**.17**	-.01	-.11	.12	.13	-.01	.07	.06	.07	.003											
Select A	-.07	-.12	.14	.03	-.09	**-.18**	-.05	-.05	-.08	-.03	.01	-.07										
Avoid B	**-.23**	-.03	**.17**	-.01	-.04	**-.26**	**-.19**	.02	**-.17**	-.07	-.10	.09	.15									
Low Risk	**-.29**	-.16	.04	.01	-.16	-.10	.05	-.07	.06	.14	-.03	.04	-.02	.06								
Risk Total	**-.29**	-.10	-.06	.10	-.15	-.07	.02	.03	.02	.11	-.07	.01	-.05	.03	**.80**							
Hours*PVP	**.79**	.07	**.18**	-.12	**.79**	**.18**	.07	**.21**	**.18**	-.08	-.01	.11	-.02	-.12	**-.26**	**-.27**						
Hours*Action	**.26**	**.83**	**-.27**	**-.32**	**.29**	.07	.13	.11	.10	-.05	.04	**.19**	-.07	-.10	**-.18**	-.15	**.19**					
Hours*Strat	**.39**	**-.21**	**.63**	**-.24**	**.46**	-.04	.01	.16	.13	-.06	-.01	.05	-.01	.01	-.10	-.15	**.59**	**-.17**				
Hours*Sim	**.53**	**-.17**	**-.16**	**.43**	.13	-.01	-.07	.13	-.05	-.01	-.04	-.02	-.06	-.09	-.10	-.06	**.29**	-.14	-.10			
PVP*Action	**.18**	**.78**	**-.25**	**-.30**	**.44**	.06	.09	.14	.02	-.13	.06	.16	-.06	.01	-.12	-.07	**.25**	**.81**	-.16	-.13		
PVP*Strat	**.26**	**-.22**	**.68**	**-.26**	**.62**	-.01	-.01	**.19**	.13	-.06	.01	.07	-.07	-.00	-.03	-.07	**.52**	**-.18**	**.80**	-.11	**-.17**	
PVP*Sim	**.22**	**-.22**	**-.22**	**.58**	**.22**	.13	.08	**.17**	-.10	.11	-.11	-.07	.04	.01	-.07	-.03	**.23**	**-.19**	-.14	**.67**	**-.17**	-.15

p < .05.

Hours was positively correlated with PVP (*r* = .55), PVP x action games (*r* = .18), PVP x strategy games (*r* = .26), and PVP x simulation games (*r* = .22). Action gaming was positively correlated with PVP (*r* = .20). Strategy gaming was positively correlated with PVP (*r* = .24) and hours x PVP (*r* = .18). Simulation games were negatively correlated with PVP (*r* = -.19). The number of pathological gaming symptoms was positively correlated with hours x action games (*r* = .29) and hours x strategy games (*r* = .46). These data indicate that as the number of hours spent gaming per week increases, so does the number of pathological symptoms. This relationship may be stronger for action and strategy games than for simulation games, which is not unsurprising given that these genres tend to be more popular among avid gamers (The NDP Group, 2010).

Self-reported impulsivity was positively correlated with hours (*r* = .18) and hours x PVP (*r* = .18), consistent with previous work (Gentile et al., 2011). Accuracy on the UFOV task was not significantly correlated with hours, action games, or hours x action games, which is inconsistent with previous work (Feng et al., 2007; Green et al., 2009). However, UFOV was positively correlated with PVP (*r* = .28), hours x PVP (*r* = .21), PVP x strategy games (*r* = .19), and PVP x simulation games (*r* = .17). That higher UFOV accuracy would be related to a greater number of pathological symptoms and the interaction between PVP and hours is interesting. This suggests that the relationship between gaming and performance on the UFOV may not be as straightforward as previously thought.

The IGT was positively correlated with hours x PVP (*r* = .18), which would be consistent with the idea that heavy screen time and pathology would be related to decreased learning from negative outcomes (e.g., continued selection from the bad decks). Along the same lines, sensitivity to negative feedback in the probabilistic selection task was correlated with hours (*r* = -.23), with participants with fewer hours also being more sensitive to negative outcomes. Sensitivity to negative feedback was positively correlated with strategy games (*r* = .17), consistent with the tendency of this genre to encourage players to learn from mistakes and avoid making them in the future. Selection of the earlier, smaller reward in the temporal discounting task was positively correlated with action games (*r* = .17) and hours x action games (*r* = .18), consistent with the hypothesis that gaming can shift the individual's focus to immediate rewards. Finally, the percentage of low risk selections in the risk task was negatively correlated with hours (*r* = -.29), hours x PVP (*r* = -.26), and hours x action (*r* = -.18), consistent with greater risk taking among gamers. The total score in the risk task was also negatively correlated with hours (*r* = -.29) and hours x PVP (*r* = -.27), demonstrating that selecting the riskier option more frequently has a detrimental effect on overall gains for the high gamers, consistent with the hypothesis that video games would be associated with greater risk taking.

Linear Regression Analyses. To determine whether the video game measures could explain self-reported impulsivity, attitudes towards risk, and performance on the tasks, a linear regression was conducted for each of the dependent variables with the predictors sex, hours, action, strategy, simulation, and PVP entered in Model 1 (Table 2.4a) and the seven interaction terms entered in Model 2 (Table 2.4b). The data for the continuous variables were mean-centered in order to control for the effects of multicollinearity (Enders & Tofighi, 2007). When an interaction term was significant, the simple effects were tested to determine if there

Table 2.4. Results of the Individual Regression Analysis for Each Dependent Variable.

	a) Model 1		Sex	Hours	Action	Strat	Sim	PVP	b) Model 2		Hours*PVP	Hours*Action	Hours*Strat	Hours*Sim	PVP*Action	PVP*Strat	PVP*Sim
	R^2	*F*	r_p	r_p	r_p	r_p	r_p	r_p	R^2	*F*	r_p	r_p	r_p	r_p	r_p	r_p	r_p
BIS-11	.08	1.94	-.004	-.11	-.12	**-.19**	**-.18**	.08	.23	**3.03**	.09	-.16	**-.27**	**-.35**	**.18**	**.21**	**.32**
RAS	.06	1.53	-.15	.03	.01	-.06	-.05	.02	.14	1.62	-.08	-.06	-.03	**-.21**	-.05	-.05	.08
UFOV	.21	**6.14**	**-.32**	-.01	-.003	.07	**.20**	.10	.24	**3.33**	-.02	-.02	-.03	-.04	**.20**	**.17**	**.15**
IGT	.04	1.02	-.01	.13	-.07	-.01	-.12	-.02	.12	1.37	**.18**	.11	-.10	-.06	.05	.12	.04
SSD	.03	.74	.04	-.06	-.03	-.07	.04	-.01	.07	.76	.003	.09	.03	-.03	-.05	.04	.07
SSRT	.01	.26	.01	.04	.001	-.001	-.08	-.02	.03	.33	-.06	-.05	-.05	-.02	.04	.01	-.04
Discount	.04	1.00	.03	.05	.11	.01	-.02	.05	.06	.61	.02	.06	-.01	.02	.02	.06	.01
Select A	.05	1.11	.08	.002	.04	.16	.07	-.06	.11	1.31	.14	-.003	-.06	-.11	.01	-.06	.06
Avoid B	.10	**2.66**	.06	**-.23**	.10	**.19**	.09	.06	.14	1.72	.04	-.07	.06	.04	.04	-.07	.03
Low Risk	.12	**3.16**	.07	**-.26**	-.12	-.04	-.10	.05	.14	1.74	-.09	-.02	.02	.07	.08	.06	.02
Risk Total	.10	**2.64**	.03	**-.26**	-.06	-.06	.01	.05	.13	1.54	-.10	-.04	.01	.07	.07	.06	.003

Note: Sex and video game measures were entered into Model 1 and interactions between video game measures were entered in Model 2. Partial correlations are reported. **p<.05**.

were significant differences in the levels of one variable across the levels of the second variable. To simplify these analyses, the data were split into three groups for hours (0, < 30, $\geq$ 30) and PVP (no symptoms, < 6, $\geq$ 6).

For the BIS-11, Model 1 did not explain a significant proportion of the variance; however, categorization as a strategy gamer predicted lower self-reported impulsivity (non-strat: *M* = 65.89, *SD* = 4.71; strat: *M* = 64.44, *SD* = 1.42), as did categorization as a simulation gamer (non-sim: *M* = 66.14, *SD* = 3.84; sim: *M* = 64.21, *SD* = 4.70; Table 2.4a). This may reflect the greater importance of planning in these genres compared to others (e.g., action). Model 2 explained a significant proportion of the variance and hours x strategy, hours x simulation, PVP x action, PVP x strategy, and PVP x simulation predicted BIS-11 scores (Table 2.4b, 2.5). BIS-11 scores were higher for non-strategy gamers who played 30 or more hours per week than for strategy gamers who played the same amount (Figure 2.1a); participants who did not currently play video games, but identified as simulation gamers, scored higher on the BIS-11 than non-gaming, non-simulation participants (Figure 2.1b). These data suggest that playing strategy video games may reduce impulsivity. In the interactions with PVP, action gamers had

Table 2.5. Results of the Simple Effects Tests of Significant Interactions.

			R^2	*F*	r_p
BIS-11	Hours	Non-strat	.06	2.38	.17
		Strat	.04	.42	.02
		Non-sim	.10	**3.77**	**.28**
		Sim	.40	**9.18**	**-.31**
	PVP	Non-action	.04	1.59	.06
		Action	.03	.34	.06
		Non-strat	.06	2.38	.06
		Strat	.04	.42	.19
		Non-sim	.10	**3.77**	-.05
		Sim	.40	**9.18**	**.44**
RAS	Hours	Non-sim	.05	1.80	.19
		Sim	.31	**6.15**	**-.36**
UFOV	PVP	Non-action	.19	**7.47**	.05
		Action	.21	**2.90**	.27
		Non-strat	.12	**4.92**	.06
		Strat	.30	**4.52**	.13
		Non-sim	.19	**7.47**	.14
		Sim	.22	**3.91**	.08
IGT	Hours	No Symptoms	.04	1.19	-.21
		< 6 Symptoms	.03	.70	.07
		> 6 Symptoms	.29	1.64	**.53**

p < .05.

higher BIS-11 scores than non-action gamers when they endorsed six or more pathological symptoms (Figure 2.2a), consistent with the hypothesis that pathological use of action video games is associated with greater impulsivity. BIS-11 scores were lower for strategy gamers than non-strategy gamers when symptoms were present (Figure 2.2b), further supporting the idea that strategy games may in fact reduce self-reported levels of impulsivity. In contrast, simulation gamers scored lower than non-simulation gamers when no symptoms were endorsed (Figure 2.2c).

For self-reported attitudes towards risk, neither of the models explained a significant proportion of the variance (Table 2.4). The interaction between hours and simulation games was a significant predictor of attitudes towards risk (Table 2.4b, 2.5). Non-simulation gamers had slightly greater acceptance of risk than simulation gamers when playing video games for 30 or more hours a week (Figure 2.3a).

For the UFOV task, Model 1 explained a significant proportion of the variance (Table 2.4a). Sex predicted UFOV accuracy (Males: *M* = .79, *SD* = .09; Females: *M* = .60, *SD* = .07) as did playing simulation games (non-sim: *M* = .68, *SD* = .13; sim: *M* = .74, *SD* = .11; Table 2.4a). Model 2 explained a significant proportion of the variance in UFOV accuracy (Table 2.4b) and PVP x action, PVP x strategy, and PVP x simulation significantly predicted UFOV accuracy (Table 2.5; Figure 2.4). When no symptoms of pathology were present, non-strategy gamers were more accurate than the strategy gamers (Figure 2.4b); and simulation gamers were more accurate than non-simulation gamers (Figure 2.4c).

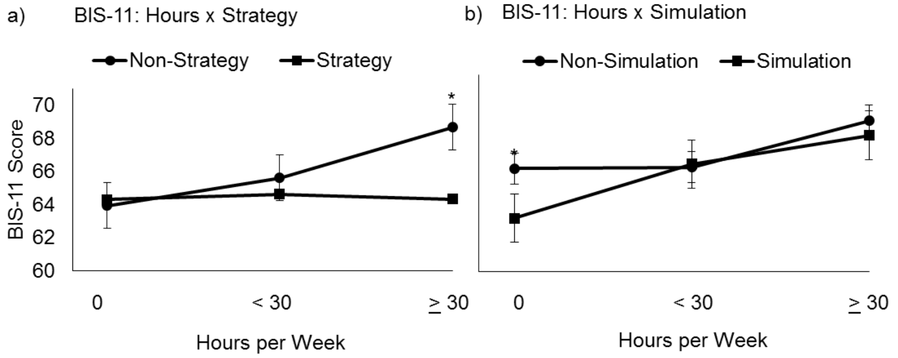

Figure 2.1. Interactions between hours and genre predict BIS-11 scores. *Difference between groups is significant at $p < .05$. Error bars represent the standard error of the mean.

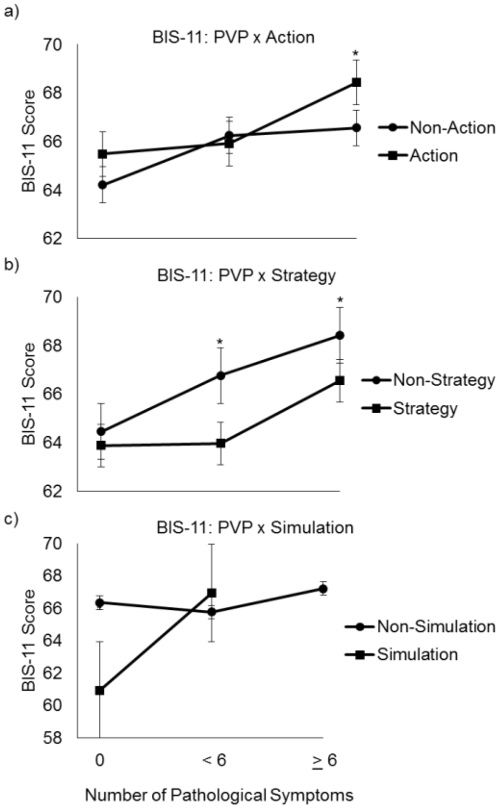

Figure 2.2. Interactions between PVP and genre predict BIS-11 scores. *Difference between groups is significant at $p < .05$. Error bars represent the standard error of the mean.

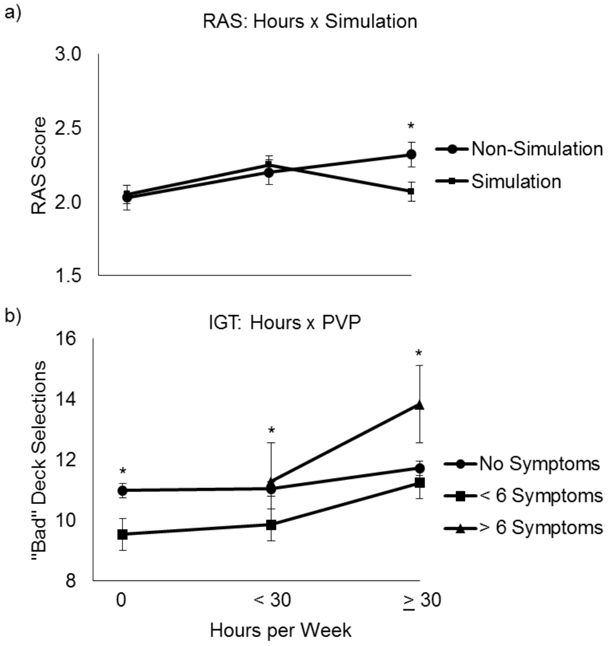

Figure 2.3. a) Hours x simulation and attitudes towards risk. b) Hours x PVP and selections from the "bad" deck in the IGT. *Difference between groups is significant at $p < .05$. Error bars represent the standard error of the mean.

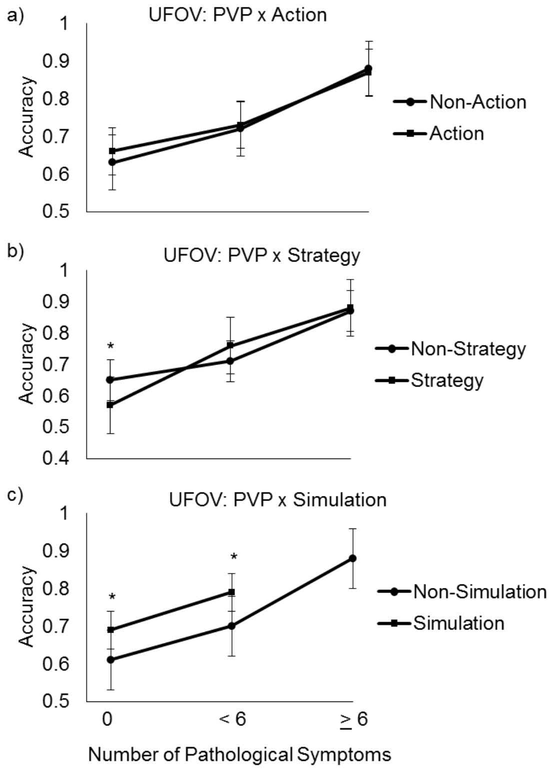

Figure 2.4. Interactions between PVP and genre predict UFOV accuracy. *Difference between groups is significant at *p* < .05. Error bars represent the standard error of the mean.

These findings are surprising given the number of studies indicating that action video games benefit visuospatial processing. One would expect that action games would predict accuracy on the UFOV, but it does not. The interactions between PVP and genre are also surprising in that it appears that more symptoms predicts better performance on the UFOV, which seems counterintuitive as pathology is usually associated with worse performance.

For the IGT, neither of the models explained a significant proportion of the variance. The interaction between hours and pathological symptoms was a significant predictor of selection from the “bad” decks (Table 2.4b, 2.5). Non-gamers with no symptoms selected from the “bad” decks more often than individuals who endorsed some symptoms (Figure 2.3b). Among participants who played 30 or fewer hours per week, those who endorsed less than six symptoms made fewer selections from the “bad” decks than those with no symptoms or those with six or more. Pathological gamers playing 30 or more hours per week selected from the “bad” decks significantly more than those without pathology. These data indicate that pathological gaming is associated with reduced sensitivity to negative outcomes.

For the stop-signal and temporal discounting tasks, neither of the models explained a significant proportion of the variance (Table 2.4). The video game measures and sex were not significant predictors of performance on these tasks.

For the probabilistic selection task, neither model explained a significant proportion of the variance for selecting A (Table 2.4). Model 1 explained a significant proportion of the variance for avoiding B, with males (*M* = .64, *SD* = .07) being less likely to avoid B than females (*M* = .66, *SD* = .10) and strategy gamers (*M* = .72, *SD* = .08) being more likely to avoid B than non-strategy gamers (*M* = .63, *SD* = .08; Table 2.4a). The latter may reflect the fact that learning from errors in a strategy game is important for making more successful decisions in the future.

For the risk task, Model 1explained a significant proportion of the variance in low risk selections and the total score at the end of the task (Table 2.4a). Individuals who did not play video games selected the low risk option on 86.26% (*SD* = .03) of the trials on average and finished the task with an average of 476 points (*SD* = 115). Individuals who play less than 30 hours per week selected the low risk option on an average of 84.40% (*SD* = .04) of the trials and finished the task with an average of 416 points (*SD* = 141). Finally, individuals who play 30 hours or more per week selected the low risk option on an average of 77.72% (*SD* = .05) of the trials on average and completed the task with an average of 57 points (SD = 254). The amount of time spent playing video games predicted riskier choices and significantly worse performance on the task.

Canonical Correlations. The linear regression analysis revealed which of the independent variables could predict each of the dependent variables, separately. In order to test the relationship between the independent variables and the set of dependent variables, I conducted a canonical correlation analysis using hours, PVP, action, strategy, simulation, and the seven interaction terms as predictors of the other measures. This analysis evaluated the multivariate shared relationship between the two sets of variables (i.e., video game experience and decision making). Because the regression analyses revealed that the dependent variables for the stop-signal task were not correlated or predicted by any of the video game measures, SSD and SSRT were not included in the canonical correlation analysis. Tests of the dimensionality of the canonical correlations revealed nine dimensions, of which the first two were significant (Table 2.6). The first canonical dimension had a correlation of *r* = .62 between the independent and dependent variable sets. The second canonical dimension had a correlation of *r* = .53 between the variable sets. These correlations indicate that the two sets of variables were highly correlated (Sherry & Henson, 2005).

Table 2.6. Tests of Canonical Dimensions.

Dimension	Canonical Correlation	*F*	df1	df2	*p*
1	0.62	1.7	117	955	.001
2	0.53	1.3	96	866	.03
3	0.44	1	77	775	.44
4	0.37	.82	60	681	.83
5	0.33	.65	45	585	.96
6	0.23	.44	32	485	.99
7	0.17	.34	21	380	.99
8	0.13	.26	12	266	.99
9	0.07	.14	5	134	.98

The canonical correlations between the variables (independent and dependent) and the dimensions indicate which variables have the most influence on the dimension and can be interpreted in a similar manner as the factor loadings in a factor analysis (Afifi, Clark, & May, 2004). In a sample of 148, an r of .30 is significant at the .001 level, therefore variables where $r \geq .30$ were considered statistically significant (Table 2.7). For the dependent variables, the first canonical dimension explained 11.12% of the variance and was most strongly related to RAS ($r = -.84$), UFOV ($r = .56$), Risk Total ($r = .38$), Avoid B ($r = .34$), Choose A ($r = .32$), and BIS-11 ($r = .30$). For the video game measures and sex, the first dimension explained 5.34% of the variance and was most strongly related to hours x PVP ($r = .67$), hours ($r = .62$), sex ($r = -.53$), PVP ($r = .52$), and hours x action ($r = .35$). This dimension reflects the association between screen time and pathological gaming on risk-taking and sensitivity to negative and positive feedback.

Table 2.7. Canonical Correlations After Varimax Rotation of the Dependent Variables.

	Canonical Dimension	
	1	2
Dependent Variables		
BIS-11	.30	.74
RAS	-.84	-.23
UFOV	.56	.29
IGT	.27	.26
Discount	.02	-.14
Choose A	.32	.17
Avoid B	.34	.10
Low Risk	.19	-.32
Risk Total	.38	.59
Video Game Measures and Sex		
Sex (1 = male, 2 = female)	-.52	-.64
Hours	.62	.33
Action	.19	.38
Strat	.07	-.23
Sim	-.21	.19
PVP	.52	.34
Hours*PVP	.67	.21
Hours*Action	.35	.36
Hours*Strat	.27	.20
Hours*Sim	.04	.28
PVP*Action	.24	.27
PVP*Strat	.23	.23
PVP*Sim	.25	-.01

For the dependent variables, the second dimension explained 8.08% of the variance and was most strongly related to BIS-11 (*r* = .74), Risk Total (*r* = .59), and low risk selections (*r* = -.32). For the video game measures and sex, the second dimension explained 2.94% of the variance and was related to sex (*r* = -.64), action (*r* = .38), hours x action (*r* = .36), PVP (*r* = .34), and hours (*r* = .33). This dimension reflects the relationship between playing action video games and increases in impulsivity.

Discussion

Study 1 was designed to examine the association between exposure to video games and various measures of risky decision making, impulsivity, and sensitivity to feedback. Consistent with previous work examining video game play and pathological video game use in children and adolescents (Gentile, 2009), approximately 7% of the current sample of young adults met criteria for pathological gaming. Males reported spending more time playing video games and more symptoms of pathological gaming than females. The number of hours spent playing video games per week was positively correlated with the number of pathological symptoms. In addition to replicating past research in this area (Gentile et al., 2011), the current study also found evidence for differential effects of genre and pathology on impulsivity, risk-taking, and reinforcement learning.

Gaming and Impulsivity: Trigger Happy or Patience is a Virtue?

The interaction between hours and PVP was positively correlated with BIS-II scores supporting the idea that pathological gaming is associated with greater impulsivity, as previously demonstrated (Gentile et al., 2011). The data also revealed evidence that the genre of video game influenced the relationships among these variables. In the temporal discounting task, selection of smaller, earlier rewards was associated with playing action video games as well as the amount of time spent playing action video games, indicating greater impulsivity among heavy action gamers. The regression analyses further revealed that playing action, but not strategy or simulation, video games predicts greater impulsivity among participants who are pathological gamers. This was confirmed by the second dimension of the canonical correlation which represented the effect of hours, action games and pathology on impulsivity. These findings seem consistent with the cognitive control research, suggesting that high gamers rely more on reaction to the situation rather than planning (Bailey et al., 2010).

In stark contrast to action games, playing strategy or simulation games predicted lower impulsivity. Interestingly, strategy gamers were less impulsive than non-strategy gamers when they played 30 or more hours a week and when they reported symptoms of pathology. It seems counterintuitive that individuals who are exposed to high doses of video games or display symptoms of pathological gaming would be less impulsive (Gentile et al., 2011), but the nature of strategy video games, unlike action games, encourages careful planning and deferred gratification. There are also more likely to be social repercussions for making hasty decisions in a strategy game, as successful completion of the goals often requires cooperation as a team. It is important to note that both strategy games and action games were positively correlated with PVP and the correlation between pathological symptoms and hours x strategy (*r* = .46) appeared to be higher than the correlation between

PVP and hours x action (r = .29), although this difference did not reach significance, $t(146) = 1.53$, $p > .05$.. This pattern suggests that strategy and action games are linked to pathology, but the consequences for impulsivity are reversed, likely due to the structure of the environment and the goals of the different genres.

Gaming and Risk-Taking: High Stakes with No Gains

In addition to greater impulsivity, gaming and action games in particular were linked to riskier decision making. In the risk task, the number of hours spent playing video games, the interaction between hours and PVP, and categorization as an action gamer were all negatively correlated with the percentage of low risk selections. Furthermore, hours predicted selecting the high-risk option more frequently. This was accompanied by a dramatic difference in the total points earned at the end of the task, indicating that the greater selection of risky options did not pay off in the end. The influence of hours, pathology and action games was further confirmed in the second dimension of the canonical correlation analysis. Taken together, these findings provide evidence that screen time, pathology, and action games influence an individual's selection of risky options. This behavior apparently continues even though it may be detrimental to their overall performance as evidenced by the relationship between these variables and the total score; more hours also predicted lower total scores at the end of the task.

Similarly, selection from the "bad" decks in the IGT was positively correlated with hours x PVP. Pathological gamers who played for 30 or more hours a week selected more frequently from the "bad" decks than individuals who played for as many hours but were not pathological. Continued selection from the "bad" decks could indicate that the individuals failed to learn which decks were disadvantageous, that they were unable to change their strategies even though they knew the decks were worse overall, or they were more willing to risk larger losses for the (small) chance of receiving larger gains (Bechara, Tranel, Damasio, & Damasio , 1996). When considered with the findings from the risk task, it appears that gaming and pathology influence how likely the individual is to accept a higher risk of a large loss in favor of the smaller chance of a large gain.

Gaming and Sensitivity to Outcomes: What Did We Learn?

The probabilistic selection task was developed to determine if an individual is more sensitive to positive, negative or both types of feedback in a probabilistic learning paradigm (Frank et al., 2004). The data revealed that increased screen time was associated with a decrease in avoiding B (i.e., learning from negative feedback), while there was no correlation between hours and selecting A (i.e., learning from positive feedback). However, strategy games were positively correlated and predicted avoidance of B, suggesting that individuals who identify as strategy gamers are more sensitive to negative feedback. As with impulsivity, the characteristics of strategy games may explain this relationship. Mistakes in a strategy game can have long-term consequences for achieving goals in the game because game play usually spans a longer time frame than an action video game. There is also the added social pressure of having other players depend on your performance. In other words, mistakes in a strategy video game can be costly, and one would benefit from paying attention to negative outcomes and learning to avoid those outcomes in the future.

Performance on the risk task and the IGT may also provide some evidence that gaming and pathology are associated with decreased sensitivity to negative outcomes. Screen time predicted worse performance on the risk task (e.g., lower total score) due to greater selection of risky options. Presumably, after several selections of the low chance risky options, the accruement of losses should be a deterrent for further selection of the risky option, but this was apparently not the case. Similarly, feedback over several trials of the IGT should result in decreased selection from the “bad” decks or else the points earned would begin to fall into the negative (which is indeed what happens). Pathology and screen time together predict greater selection from the “bad” decks well past the point at which the feedback was effective at decreasing selection from these decks among non-pathological high gamers.

As mentioned previously, two possible interpretations of performance on the IGT are failure to learn (possibly due to insensitivity to feedback) or a greater willingness to take high risks for the opportunity to receive large gains. Other findings in the current data provide evidence for both of these possibilities, and the two may not be mutually exclusive. Kim et al. (2011) demonstrated greater risk-taking in a gambling task and slower learning on the IGT among patients suffering from alcohol abuse. It is possible that exposure to video games and pathological gaming may result in greater willingness to take risks because these individuals are slower to learn from negative outcomes.

Gaming and UFOV: Pathology Makes Perfect?

Based on past research, it was predicted that action video games would be related to improved accuracy on the UFOV (Green & Bavelier, 2003; Feng et al., 2007). In the current study, UFOV was not correlated with action games or with the number of hours spent playing action games. UFOV performance was positively correlated with PVP and hours x PVP. For strategy gamers, accuracy was decreased compared to non-strategy gamers when no pathological symptoms were present, which is consistent with the expectation that strategy games would not improve the useful field of view (Basak et al., 2008). Simulation gamers were more accurate than non-simulation gamers regardless of the number of pathological symptoms. Previous work has demonstrated the efficacy of flight simulation video games for testing performance in pilots (Gopher, Weil, & Bareket, 1994; Jones, Kennedy, & Bittner, 1981), suggesting that playing simulation games may influence performance on some visual and spatial tasks, likely depending on the specific content of the simulation games in question (e.g., *Air Combat*, *The Sims*, *Rock Band*). While there is not necessarily any reason to expect that pathological gaming would interfere with UFOV performance, it is interesting that as symptoms increase, so does accuracy, across all types of video games. That action games were not correlated with or predictive of UFOV performance does throw suspicion on the robustness of the effect of action video games on the spatial distribution of vision in this task (Boot et al., 2008; Feng et al., 2007; Green & Bavelier, 2003).

Summary

Study 1 was largely exploratory given the small number of studies that have examined the relationship between decision making under risk and video games (Beullens et al., 2011; Fischer et al., 2009; Pawlikowski & Brand, 2011). The data provided ample evidence that video games and pathology can predict impulsivity and risky decision making. Studies 2 and 3 were designed to extend these findings in two ways. In Study 2, the relationship between individual differences in gaming experience and pathology and the neural correlates of risky decision making was examined. Study 3 endeavored to determine whether exposure to video games primes changes in risk-taking and sensitivity to negative outcomes.

CHAPTER 3. STUDY 2

Study 1 found that video game experience was associated with greater risk taking and decreased sensitivity to negative feedback. The number of hours spent playing video games, the interaction between hours and pathological video game use, and categorization as an action gamer were negatively correlated with the percentage of low risk selections in the risk task, and increased screen time was also associated with a decrease in avoiding B in the probabilistic selection task and continued selection from the “bad” tokens in the IGT task, indicating reduced sensitivity to negative feedback. Study 2 was designed to extend the findings of Study 1 by examining the relationship between video game experience and the neural correlates of risky decision making and reinforcement learning using ERPs. Data were collected in two phases; in Phase 1, pilot data on a computerized version of blackjack were collected from individuals recruited as low or high action video game players. The preliminary data looked promising, so in Phase 2 additional participants completed the risk task and probabilistic selection task from Study 1 and blackjack while EEG was recorded.

In addition to the FRN that has been extensively studied in decision making and gambling tasks (Hajcak et al., 2005; Hewig et al., 2007; Holroyd et al., 2003), the current study also examined the association between video game experience and the $P2_w$, or positivity effect for wins, the P3, and the slow wave. The $P2_w$ reflects sensitivity to unexpected rewards in gambling tasks (Hewig et al., 2010; Potts, Martin, Burton, & Montague, 2006) and reinforcement learning tasks (Holroyd & Coles, 2002) and has a similar topography as the FRN, but is a transient positivity.

The P3 component is related to evaluative processes or the orienting of attention to stimuli and has been recorded in various paradigms (Courchesne, 1978; Ito, Larsen, Smith, & Cacioppo, 1998; Johnson & Donchin, 1980). The P3 is sensitive to individual difference variables (Bartholow, 2010; Polich, 2007), including video game experience (Engelhardt, Bartholow, Kerr, & Bushman, 2011; Bartholow et al., 2006). The slow wave is typically observed over the lateral frontal and posterior regions of the scalp, and likely reflects the updating of task goals (Bailey et al., 2011; West & Travers, 2008).

In the blackjack task, the data from Phases 1 and 2 were combined and the individuals recruited as gamers were subdivided based on the number of hours they reported playing video games per week. This was done in order to examine whether differences in amount of exposure (i.e., screen time) to video games was associated with differences in the ERPs. Losses were expected to elicit the FRN and I hypothesized that the P3 would be greater for losses than for wins. Slow wave activity that differentiated wins from losses was also expected. I hypothesized that the video game players would be less sensitive to negative outcomes as indexed by attenuation of the FRN, P3, and slow wave activity elicited by feedback indicating a loss.

In Phase 2, high and low gamers completed the risk task and probabilistic selection task from Study 1, and the blackjack task from Phase 1 while ERPs were recorded. Given the novelty of using ERPs with these two tasks, the study was to some extent exploratory; however, it was hypothesized that the FRN would be sensitive to feedback in both tasks (i.e., greater amplitude for negative feedback), and that the amplitude of the P3 would be sensitive to the level of risk and changes in the probability of correct feedback in the risk task and probabilistic selection, respectively (i.e., greater in amplitude for risky wins and low probability outcomes). Based on Study 1, I hypothesized that high gamers would be less sensitive to negative outcomes than low gamers and this would be represented by attenuation of the FRN and P3 in the high gamers. Additionally, unexpected positive feedback should elicit the $P2_w$ component. Participants also completed the UFOV task in order to demonstrate that the high gamers in the current study were similar to the action gamers in studies of visuospatial processing (Feng et al., 2007; Green & Bavelier, 2003).

Method

Participants

Ninety-eight males from Iowa State University were recruited to participate in this study based on their responses to the media usage questionnaire which they completed twice; once at least 2 weeks prior to participation in the laboratory session as part of a larger screening exercise, and once at the end of the laboratory session. Individuals who reported spending two or fewer hours per week playing any genre of video game at the time of screening were recruited as low gamers. Individuals that reported spending ten or more hours per week playing video games and reported that they often or always played first-person shooter video games at the time of screening were recruited as high gamers.

For the blackjack task, the data for seven participants were excluded from the analyses due to misunderstanding how to play (1), excessive artifact in the EEG data (1), or a large (i.e., $\geq$ 5 hours) increase or decrease in the number of hours reported playing video games per week between the initial screening and laboratory session (5), leaving 91 participants in the sample. Data were randomly selected from half of the 52 individuals recruited as low gamers to be included in the analyses of the blackjack task (*M* = 0 hours per week; see Bailey et al., 2011 for a similar approach). A median split was performed on the hours played per week for the gamers, creating a group of 20 moderate gamers (*M* = 10 hours per week, *SD* = 5) and 26 high gamers (*M* = 31 hours per week, *SD* = 12). The low gamers (*M* = 20.62, *SD* = 5.29), moderate gamers (*M* = 18.65, *SD* = .75), and high gamers (*M* = 19.5, *SD* = 1.75) were similar in years of age (*F*(2,71) = 1.97, *p* = .15) and in their distribution of handedness (low gamers, right = 21, ambidextrous = 3, left = 2; high gamers, right = 23, ambidextrous = 3; moderate gamers, right = 18, ambidextrous = 2; χ^2(4, *N* = 72) = 3.71, *p* = .45; Oldfield, 1971).

Fifty-two of the 98 participants (i.e., individuals recruited during Phase 2) completed the probabilistic selection task, the risk task, and UFOV. For these tasks, data from two participants were excluded due to poor task performance (1) or excessive artifact in the EEG data (1). The sample included 25 low gamers (*M* = .08 hours per week, *SD* = .40) and 25 high gamers (*M* = 20.48 hours per week, *SD* = 13.51). The low gamers (*M* = 20.92, *SD* = 5.42) and high gamers (*M* = 18.8, *SD* = .82) were not statistically different in years of age (*F*(1,48) = 3.75, *p* = .06) or in their distribution of handedness (low gamers, right = 22, ambidextrous = 3; high gamers, right = 23, ambidextrous = 2; χ^2(1, *N* = 50) = .22, *p* = .64; Oldfield, 1971).

For the risk task, participants who never chose the risky option were removed from the data prior to analysis in order to examine the influence of risk on the amplitude of the ERPs associated with wins and losses. This resulted in a sample of 20 low gamers and 18 high gamers. Two additional low gamers were removed for having an average reaction time > 3 *SD*s above the mean, leaving 18 participants.

Materials and Design

Questionnaires. The risk-attitudes scale (Weber et al., 2002) and media usage questionnaire were administered to assess risk taking behavior and video game usage, respectively. These measures were identical to Study 1. For the risk-attitudes scale, internal reliability was high (*coefficient* $\alpha = .81$). The media usage questionnaire was administered during a screening session and during the laboratory session. The internal reliability was good for the number of hours played per week (screening *coefficient* $\alpha = .82$, laboratory session *coefficient* $\alpha = .82$) and the test-retest reliability of this measure was high ($r = .86$). Participants in Phase 2 also completed the BIS-11 (Patton et al., 1995) and the pathological gaming scale (Gentile et al., 2011; Gentile, 2009) to assess impulsivity and pathology, respectively. These measures were identical to Study 1. Internal reliability was good for the BIS-11 (*coefficient* $\alpha = .85$). For the pathological gaming scale, internal reliability was low (*coefficient* $\alpha = .39$).

Tasks. The stimuli and design of the risk task, the probabilistic selection task, and UFOV (*coefficient* $\alpha = .91$) were identical to Study 1, with the exception that EEG was recorded while participants completed the tasks. The dependent variables remained the same as Study 1 with the addition of the mean amplitude of the ERPs.

The blackjack game was programmed in OpenGL (Silicon Graphics, Inc., Sunnyvale, CA) and was designed to look as if the participant was sitting at a casino table across from a dealer. Participants were instructed to make as much money as they could by getting their cards to equal more than the dealer's cards without going over 21. Participants were given $1000 at the start of the game. A round of play (i.e., "hand") consisted of three stages: betting, dealing, and feedback. In the betting stage, the participant placed a bet between $50 and the total amount of money he currently held. In the dealing stage, the participant and dealer were dealt two cards. The participant then decided whether he would "hit" (receive another card) or if he would "stay" (keep the cards in hand). Feedback (i.e., "You win!", "You Lose", or "Push" – indicating a tie – and total money) was displayed after the participant selected to stay or if the participant's cards equaled more than 21 (i.e., a "bust" or loss). To increase his bet and to "hit" participants pressed the "m" key and to decrease this bet or to "stay" participants pressed the "v" key. The spacebar was used to advance from the betting stage to the dealing stage and to advance from the feedback to the next hand. After instructions were given, participants practiced the game for 5 minutes. EEG data were recorded for 15 minutes of play. If the participant reached a balance of $0 before the end of that time, then the game was reset and he continued playing. The dependent variables were the amount of money the individual bet on the current trial conditionalized upon the outcome of the previous trial and the mean amplitude of the FRN and P3. The four possible outcomes of each hand are the player wins (win), the player loses to the dealer (loss), the player loses because his cards total more than 21 (bust), or the player's cards total the same as the dealer's (tie).

Procedure

The fitting of the electro-cap was briefly described to the participant when he arrived for the study. The participant gave informed consent and completed the Edinburgh Handedness Inventory, the risk-attitudes scale, and the media usage questionnaire. Participants in Phase 2 also completed the BIS-11 and pathological gaming scale at this time. After the cap was fitted, the participant was moved to the testing room and asked to sit comfortably in front of the computer monitor. Participants were asked to limit eye and head movements during recording. All participants played blackjack for 15 minutes. If the participant lost all of his money before 15 minutes thereby ending the current game, the researcher restarted the game with a $1000 balance. Phase 2 participants also completed the risk task, probabilistic selection task, and UFOV. Half of the participants completed the four tasks in the following order: risk task, UFOV, probabilistic selection, blackjack. The remaining participants completed the tasks in the reverse order. Following testing, participants were debriefed. The entire experiment took approximately 120 minutes.

Electrophysiological Recording and Analysis

The electroencephalogram (EEG) (bandpass 0.02 – 150 Hz, digitized at 500 Hz, gain 1000, 16-bit A/D conversion) was recorded from an array of 68 tin electrodes based on a modified 10-10 system using an Electro-cap (Electro-Cap International, Eaton, OH). Vertical and horizontal eye movements were recorded from electrodes placed beside and below the right and left eyes. During recording all electrodes were referenced to electrode Cz, then re-referenced to an average reference for data analysis. A .1 to 12 Hz bandpass filter was applied to the data. Ocular artifacts associated with blinks and saccades were removed from the data using a covariance-based technique including empirically derived estimates of the EEG associated with artifact and artifact free data (Electromagnetic Source Estimation; Source-Signal Imaging, San Diego). For blackjack, measurements of mean voltage were taken from 300 to 325 ms (FRN: F1, F2, FCz, Fz), 475-525 ms (P3: CPz, Pz, CP1, CP2), and 800 to 1800 ms (slow wave: lateral frontal – FT9, F9, FT10, F10 or parietal – P3, Pz, P4). The mean voltage data were analyzed in a series of 3 (gamer status: low, moderate, high) x 4 (outcome: win, loss, bust, ties) x 2, 3, or 4 (electrode) ANOVAs. The blackjack data were also analyzed using Partial Least Squares analysis (PLS; McIntosh & Lobaugh, 2004; Lobaugh, West, & McIntosh, 2001) which included data for 64 electrodes from 0 to 1000 ms after stimulus onset. The PLS analysis allows one to decompose the full time course and topography of the scalp recorded ERPs into a set of orthogonal latent variables that capture differences in mean amplitude between task conditions across time and space and is useful for identifying patterns of neural activity that are differentially sensitive to various aspects of the task (e.g., differential neural activity for busts and losses) and whether these patterns are similar across the groups (Bailey et al., 2011).

In the risk task, the FRN was measured from 300 to 400 ms after onset of the feedback at electrodes F1, Fz, F2, and FCz; the $P2_w$ was measured from 300 to 350 ms after onset of the feedback at electrodes FC1, FCz, and FC2; the P3 was measured from 400 to 600 ms after onset of the feedback at electrodes CPz and Pz. In the probabilistic selection task, the FRN was measured from 260 to 310 ms after onset of the feedback at electrode FCz and the P3 was measured from 350 to 450 ms after onset of the feedback at electrodes P3, Pz, and P4. These measurements and electrodes were selected based on visual inspection of the full electrode array and differ slightly across tasks due to differences in timing, stimulus characteristics, and task demands.

Results

Psychometric Data

Questionnaires. The low ($M = 2.13$, $SD = .44$), moderate ($M = 2.20$, $SD = .57$), and high ($M = 2.32$, $SD = .33$) gamers did not significantly differ in their attitudes towards risk-taking, $F(2, 69) = 1.18$, $p = .31$, $\eta_p^2 = .03$. The low ($M = 65.12$, $SD = 11.19$) and high ($M = 61.24$, $SD = 8.18$) gamers did not differ significantly on impulsivity, $\mathrm{t}(48) = .69$, $\mathrm{p} = .5$, or attitudes towards risk, $t(48) = 1.40$, $p = .17$ (low gamers: $M = 2.28$, $SD = .44$; high gamers: $M = 2.19$, $SD = .51$). High gamers ($M = 2.04$, $SD = 1.79$) endorsed more symptoms of pathological video game use than low gamers ($M = .60$, $SD = .76$), $t(48) = -3.70$, $p = .001$.

UFOV. The UFOV task was included to verify that the high gamers recruited for this study were comparable to the action gamers described by Green and colleagues (2009, 2007, 2003). Accuracy was significantly higher for the high gamers ($M = .87$, $SD = .09$) than the low gamers ($M = .77$, $SD = .20$; $t(48) = -2.33$, $p = .02$, $\eta_p^2 = .10$), converging with the previous literature.

The Blackjack Task

Frequency of Outcomes. The four possible outcomes did not occur with the same frequency, $F(3, 207) = 295.64$, $p = .001$, $\eta_p^2 = .81$. Ties ($M = .08$, $SD = .03$) occurred significantly less often than losses ($M = .24$, $SD = .07$), $F(1, 69) = 315.83$, $p = .001$, $\eta_p^2 = .82$. Busts ($M = .30$, $SD = .07$) occurred more frequently than losses, $F(1, 69) = 12.93$, $p = .001$, $\eta_p^2 = .16$. Wins ($M = .40$, $SD = .04$) occurred significantly more often than busts, $F(1, 69) = 82.76$, $p = .001$, $\eta_p^2 = .55$. The outcome x gamer status interaction was not significant, $F < 1.0$, $p = .87$, $\eta_p^2 = .01$, indicating that the frequency of the outcomes was not statistically different for low, moderate, and high gamers.

Table 3.1. Average Amount of Bet ($) Based on the Outcome of the Previous Trial.

		Bust	Loss	Win	Tie
Low Gamers	*M*	133.70	144.80	173.86	145.83
	SD	77.46	76.43	117.24	114.76
Moderate Gamers	*M*	105.55	108.44	140.49	141.95
	SD	84.14	67.66	151.82	129.90
High Gamers	*M*	89.23	93.03	116.17	111.60
	SD	37.97	42.86	60.88	55.83

Betting. The average amount of the bet on the current hand based on the outcome of the previous hand was examined to determine whether the participants varied their playing style based on outcome. The average betting amount for hands following each of the four outcomes was analyzed in a 3 (gamer status) x 4 (outcome) ANOVA. The main effect of outcome was significant, $F(3, 207) = 9.21$, $p = .001$, $\eta_p^2 = .12$ (Table 3.1). Post hoc comparisons revealed that the amount of the bet placed after a win was greater than after a bust, $F(1,69) = 17.21$, $p = .001$, $\eta_p^2 =$

.20, or after a loss, $F(1,69) = 12.2$, $p = .001$, $\eta_p^2 = .15$ (Bonferroni corrected, $p = .008$). None of the other comparisons were significant, F's < 5.01, p's > .03. The outcome x gamer status interaction was not significant, $F < 1.0$, $p = .57$, $\eta_p^2 = .02$. The results indicate that the participants varied betting based on previous outcomes, such that the amount of the current bet was higher after the player won a hand. Gamer status was not associated with differences in betting.

Study 1 found that screen time predicted riskier choices which resulted in dramatically reduced final scores in the risk task. For blackjack, the total amount of money the participant had at the end of the 15 minutes was analyzed to determine whether a similar effect would be found in blackjack. Low (M = \$-682.69, SD = \$1665.95), moderate (M = \$-825.00, SD = \$1625.25), and high (M = \$-84.62, SD = \$1650.74) gamers did not differ significantly in how much money they ended the game with, $F(2, 69) = 1.37$, $p = .26$, $\eta_p^2 = .04$. The direction of the means indicates that the high gamers lost the least amount of money, while the moderate gamers lost the most money. This was not consistent with Study 1 and may indicate that video game experience and the payout of a gamble may not have a linear relationship.

ERP Data. Inspection of the grand-averaged waveforms revealed that the FRN was present over the frontal-central region of the scalp and was greater for busts than the other outcomes in the low, moderate, and high gamers (Figure 3.1). The P3 was observed over the central-parietal region of the scalp and was also larger for busts. The amplitude of the P3 appeared to be smaller for the high gamers compared to the low gamers (Figure 3.1). Slow wave activity over lateral frontal and parietal regions was greater for busts and appeared to be attenuated in the high gamers (Figure 3.2). For the FRN, the main effect of outcome was significant, $F(3, 207) = 26.70$, $p = .001$, $\eta_p^2 = .28$. Post hoc analyses revealed that losses ($M = .22$ μV, $SD = 2.79$), wins ($M = .65$ μV, $SD = 2.33$), and ties ($M = -.02$ μV, $SD = 2.93$) were not significantly different, $F(2, 138) = 2.41$, $p = .10$, $\eta_p^2 = .03$, so data for these conditions were combined. The amplitude of the FRN was significantly greater for

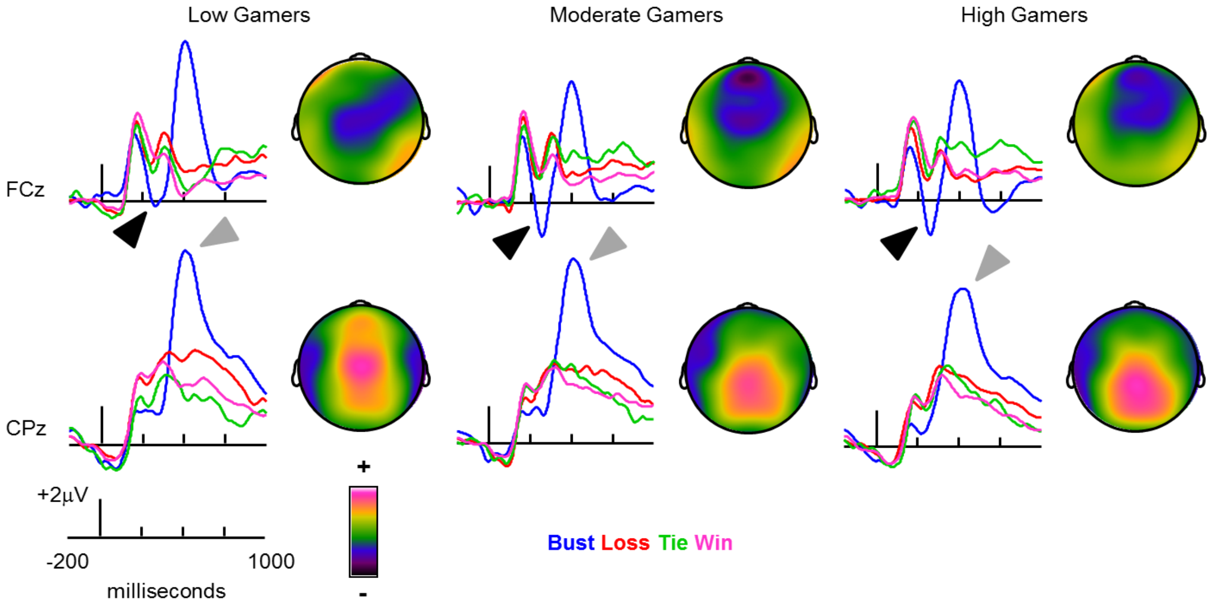

Figure 3.1. Top: Grand-averaged waveforms at FCz and topography maps illustrating the FRN (black arrows). Bottom: Grand-averaged waveforms at CPz and topography maps illustrating the P3 (gray arrows). The tall bar represents stimulus onset, the short bars represent 250 ms increments, and positive is plotted up. Topography maps reflect the difference in neural activity between busts minus wins.

busts (*M* = -2.24 μV, *SD* = 3.13) than for the other conditions (*M* = .29 μV, *SD* = 2.28), *F*(1, 69) = 48.73, *p* = .001, η_p^2 = .41. The main effect of and interactions with gamer status were not significant, *F*'s < 1.82, *p*'s > .11.

For the P3, the main effect of outcome was significant, *F*(3, 207) = 128.50, *p* = .001, η_p^2 = .65 (Figure 3.1). Further analysis revealed that the amplitude of the P3 was not significantly different for wins (*M* = 3.5 μV, *SD* = 2.08) and ties (*M* = 3.98 μV, *SD* = 3.16), *F*(1, 69) = 2.45, *p* = .12, η_p^2 = .03. The difference in P3 amplitude for ties and losses (*M* = 4.62 μV, *SD* = 2.31) was marginally significant, *F*(1, 69) = 3.35, *p* = .07, η_p^2 = .05. The amplitude of the P3 was significantly greater for busts (*M* = 9.19 μV, *SD* = 3.38) than for losses, *F*(1, 69) = 230.02, *p* = .001, η_p^2 = .77. The outcome x electrode x gamer status interaction was significant, *F*(18, 621) = 2.02, *p* = .03, η_p^2 = .06 (Table 3.2). Further analysis revealed that the outcome x gamer status interaction was marginally significant at electrode Pz, *F*(6, 207) = 2.08, *p* = .07, η_p^2 = .06, significant at electrode CPz, *F*(6, 207) = 2.50, *p* = .04, η_p^2 = .07, and not significant at electrodes CP1 or CP2, F's < 1.79, p's > .12. At electrode Pz, the amplitude of the

Table 3.2. Mean Amplitude (μV) of the P3 for the Group x Outcome x Electrode Interaction.

		Bust		Loss		Win		Tie	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Low Gamers	CPz	11.06	4.33	4.90	3.39	3.41	2.49	2.82	3.84
	CP1	10.07	3.63	4.83	2.43	3.93	2.35	3.70	3.90
	CP2	9.46	4.75	4.92	2.54	3.59	2.68	3.42	3.48
	Pz	9.17	3.71	6.28	2.98	5.34	2.66	4.18	3.75
Moderate Gamers	CPz	10.45	3.74	4.21	2.79	3.36	2.59	4.43	2.99
	CP1	8.69	2.76	3.52	2.28	2.75	1.89	4.06	2.55
	CP2	8.75	3.35	4.15	1.79	3.08	1.86	4.01	2.46
	Pz	9.19	3.03	4.59	2.31	3.67	1.68	4.72	3.06
High Gamers	CPz	9.03	3.23	4.1	2.42	2.95	2.27	3.93	3.74
	CP1	7.95	3.41	3.85	2.52	2.99	2.21	3.74	3.31
	CP2	7.91	4.01	4.36	3.17	3.18	2.98	4.19	3.92
	Pz	8.64	2.81	5.25	2.69	4.07	2.13	4.85	3.60

P3 for wins was greater in the low gamers than the moderate gamers, $t(44) = 2.46$, $p = .01$. At electrode CPz, the amplitude of the P3 for wins, losses, and ties were significantly different from one another for the low gamers, $F(2, 50) = 8.49$, $p = .002$, $\eta_p^2 = .25$, but not for the moderate or high gamers, F's < 2.55, p's > .10. For the low gamers, losses elicited a significantly larger P3 than wins, $F(1, 25) = 21.40$, $p = .001$, $\eta_p^2 = .46$, and there was not a significant difference between wins and ties $F < 1.0$, $p = .35$. These data suggests that gamer status is not associated with differences in the sensitivity to busts (i.e., negative outcome as a result of the individual's decision), but gaming may be related to reduction in the sensitivity to being beaten by an opponent (i.e., losses). Moderate amounts of video game experience may also be related to a reduction in sensitivity to wins.

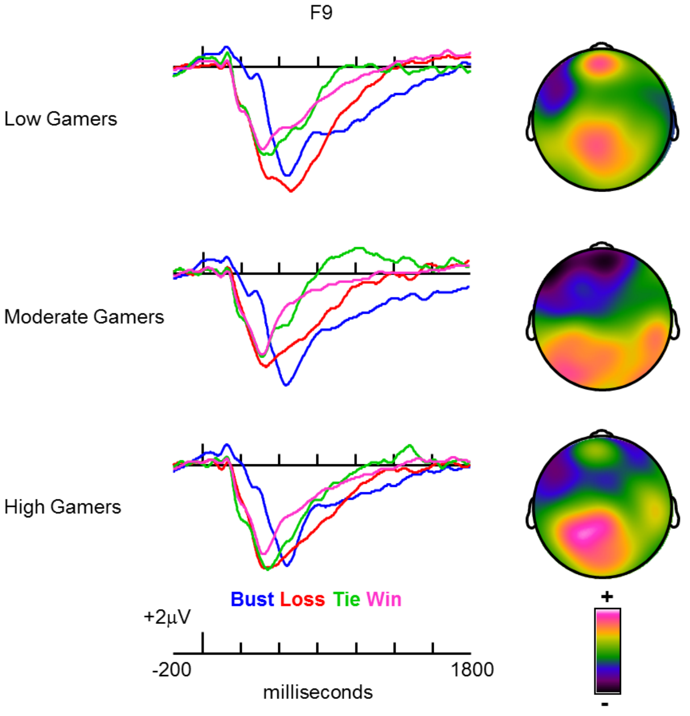

Figure 3.2. Grand-averaged waveforms and topography maps illustrating the frontal slow wave. The tall bar represents stimulus onset, the short bars represent 300 ms increments, and positive is plotted up. Topography maps reflect the difference in neural activity for busts minus wins.

Busts and losses were associated with slow wave activity over the lateral frontal, $F(3, 207) = 6.94$, $p = .001$, $\eta_p^2 = .10$, and parietal regions, $F(3, 207) = 16.76$, $p = .001$, $\eta_p^2 = .20$, between approximately 600 to 2000 milliseconds after the outcome of the hand (Figure 3.2). For the frontal slow wave the outcome x hemisphere interaction was significant, $F(3, 207) = 11.43$, $p = .001$, $\eta_p^2 = .14$ (Table 3.3). Over the left hemisphere, the amplitude of the slow wave did not differ for ties and wins, $F(1, 69) = 1.04$, $p = .31$, $\eta_p^2 = .02$, and increased from wins to losses, $F(1, 69) = 11.04$, $p = .001$, $\eta_p^2 = .14$, and from losses to busts, $F(1, 69) = 10.01$, $p = .002$, $\eta_p^2 = .13$. This may reflect greater sensitivity to losing because the player chose to take another card (i.e., a bust) than from the dealer having a better hand. Over the right frontal region, the amplitude of the slow wave was not significantly different for ties, wins, or losses, $F <$

Table 3.3. Mean Amplitude (μV) of the Outcome x Hemisphere Interaction for the Frontal Slow Wave.

		Bust	Loss	Win	Tie
Left Hemisphere	*M*	-2.75	-1.25	-0.21	0.15
	SD	4.96	4.89	4.84	5.35
Right Hemisphere	*M*	-1.99	-2.41	-2.76	-2.93
	SD	3.90	4.30	3.93	4.72

1.0, $p = .39$, $\eta_p^2 = .01$, and was less negative for busts than for the remaining conditions, $F(1, 69) = 5.35$, $p = .02$, $\eta_p^2 = .10$. Over the parietal region, slow wave activity increased from ties ($M = .82$ μV, $SD = 2.45$) to wins ($M = 1.39$ μV, $SD = 1.63$), $F(1, 69) = 5.75$, $p = .02$, $\eta_p^2 = .10$, did not differ significantly for wins and losses ($M = 1.49$ μV, $SD = 1.91$), $F < 1.0$, $p = .58$, $\eta_p^2 = .01$, and increased from losses to busts ($M = 2.47$ μV, $SD = 1.93$), $F(1, 69) = 16.38$, $p = .001$, $\eta_p^2 = .19$. This indicates greater sensitivity to the busts than the other outcomes. There were no significant interactions with gamer status, F's < 2.55, p's $> .10$.

PLS Analysis. The permutation test for the PLS analysis revealed four significant latent variables ($p = .001$, $p = .001$, $p = .012$, $p = .02$) that accounted for 64.2%, 18.37%, 5.8%, and 4.52% of the crossblock covariance, respectively.

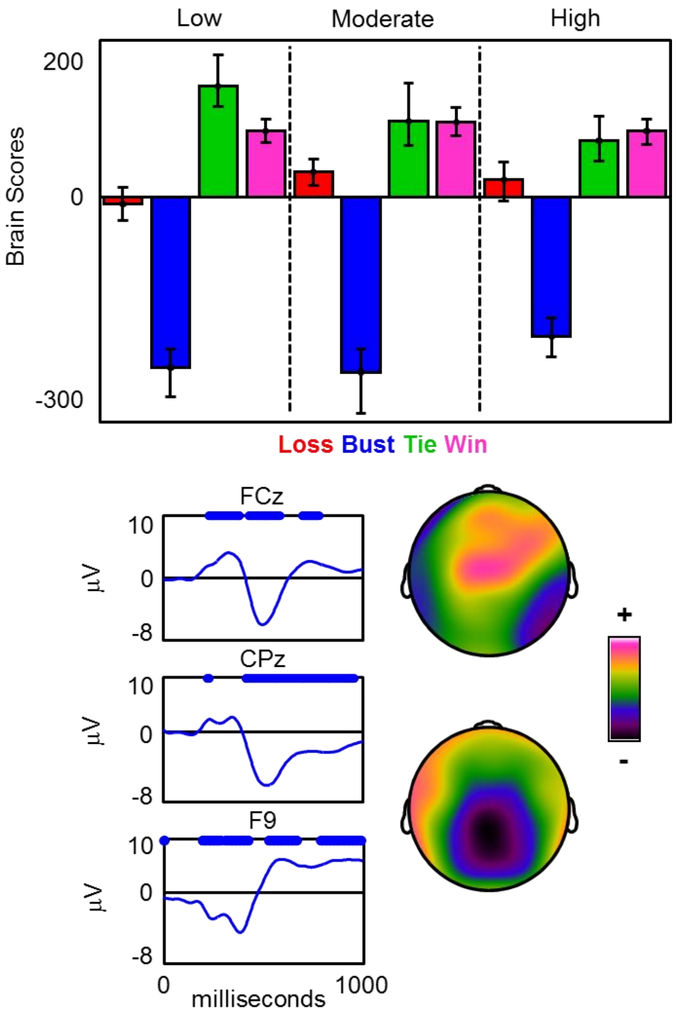

Figure 3.3. First latent variable of the PLS analysis. The upper panel portrays the contrasts (brain scores) representing significant mean differences in ERP amplitude across outcomes and gamer status. The error bars represent the 95% confidence intervals from the bootstrap test. The bottom panel portrays the electrode saliences at three select electrodes and their respective scalp topography maps highlight the temporal and spatial distribution of the effects. The (o) above the x-axis indicate electrode saliences where the bootstrap ratio exceeded 6.0. In the topography maps, lighter colors reflect positive voltage and darker colors reflect negative voltage. These results reflect greater amplitude of the FRN, P3, and slow wave for busts, and this effect is smaller in the high gamers.

The first latent variable represented a contrast between busts and the remaining outcomes (Figure 3.3). The brain score for busts was slightly smaller in the high gamers compared to the moderate and low gamers. The electrode saliences reflected three stable time points of neural activity. The first was a transient positivity over the frontal-central region from 300 to 550 ms, reflecting the FRN. The second was a negativity over the central-parietal region of the scalp from around 300 to 600 milliseconds after onset of the outcome, reflecting the P3. The third stable time point was a sustained positivity over the left frontal region and negativity over the parietal region from 500 to 1000 milliseconds following the outcome. This latent variable appears to represent neural processing underlying a loss that the participant most likely caused

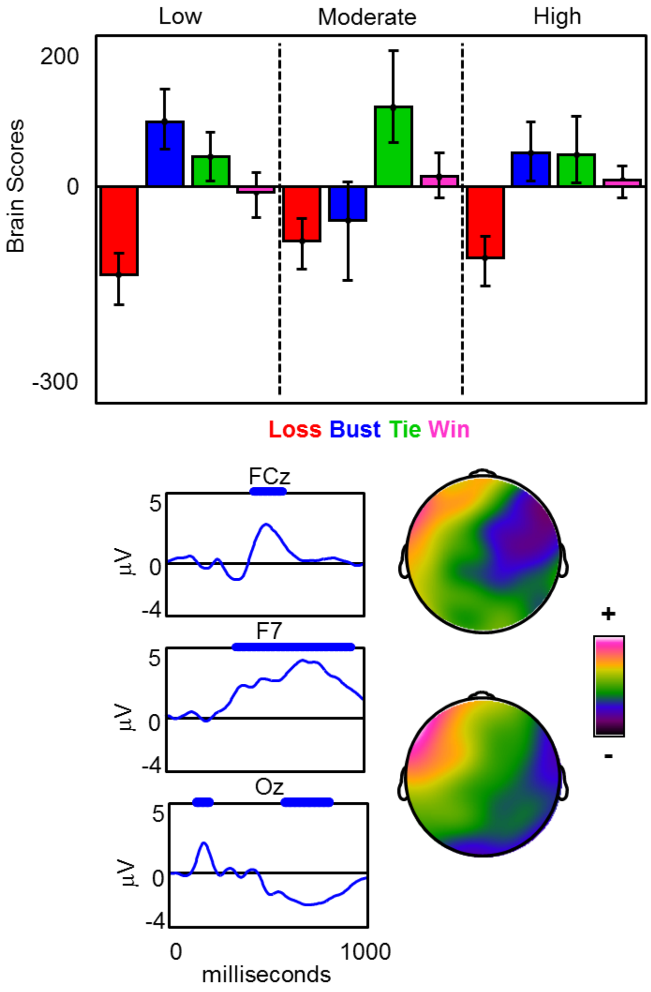

Figure 3.4. Second latent variable of the PLS analysis. The upper panel portrays the contrasts (brain scores) representing significant mean differences in ERP amplitude across outcomes and gamer status. The error bars represent the 95% confidence intervals from the bootstrap test. The bottom panel portrays the electrode saliences at three select electrodes and their respective scalp topography maps highlight the temporal and spatial distribution of the effects. The (o) above the x-axis indicate electrode saliences where the bootstrap ratio exceeded 4.0. In the topography maps, lighter colors reflect positive voltage and darker colors reflect negative voltage. These results reflect greater amplitude of the FRN and slow wave for losses, and this effect is smaller in the moderate and high gamers.

(e.g., takes another card resulting in a loss) and is consistent with the mean amplitude analyses. There was some evidence that the high gamers may be less sensitive to this type of loss compared to low and moderate gamers.

The second latent variable represented a contrast between losses and the remaining outcomes, and this effect was smaller in the moderate gamers and slightly decreased in the high gamers relative to the low gamers (Figure 3.4). The electrode saliences reflected two stable time points of neural activity. The first was a transient negativity over the frontal-central region of the scalp between 400 to 600 milliseconds after onset of the outcome, which reflects the FRN. The second stable time point was a sustained positivity over the left frontal region accompanied by negativity over the parietal region around 500 to 1000 milliseconds.

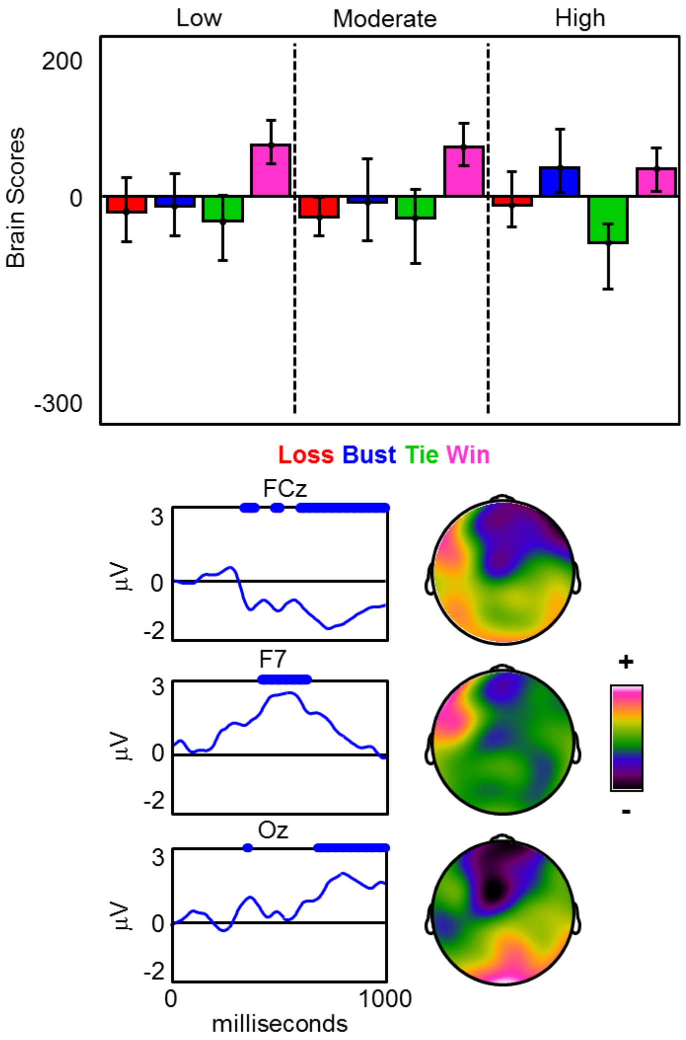

Figure 3.5. Third latent variable of the PLS analysis. The upper panel portrays the contrasts (brain scores) representing significant mean differences in ERP amplitude across outcomes and gamer status. The error bars represent the 95% confidence intervals from the bootstrap test. The bottom panel portrays the electrode saliences at three select electrodes and their respective scalp topography maps highlight the temporal and spatial distribution of the effects. The (o) above the x-axis indicate electrode saliences where the bootstrap ratio exceeded 3.0. In the topography maps, lighter colors reflect positive voltage and darker colors reflect negative voltage. These results reflect greater amplitude of the $P2_w$ and slow wave for wins, which appears smaller in high gamers.

This latent variable appears to represent processing that is specific to losses, and this effect may be sensitive to moderate levels of video game exposure.

The third latent variable appeared to represent neural processing related to wins, and was attenuated in the high gamers (Figure 3.5). The electrode saliences revealed three stable time points of neural activity. The first was a transient negativity over the frontal-central electrodes around 300 to 400 milliseconds, representing the $P2_w$ (Hewig et al., 2010). The second was a sustained positivity over the left frontal region around 600 to 800 milliseconds, followed by a sustained positivity over the parietal-occipital region of the scalp from 800 to 1000 milliseconds. The meaning of this contrast is not immediately apparent. However, inspection of the grand average waveforms indicates that this effect actually

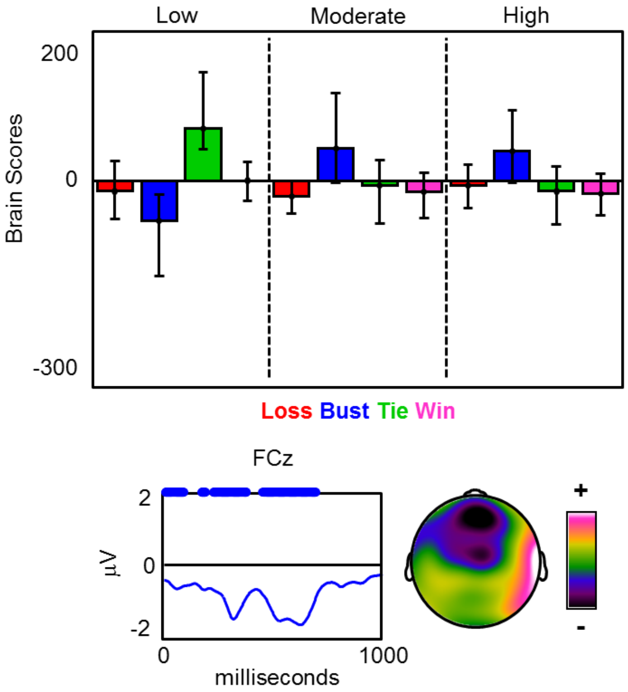

Figure 3.6. Fourth latent variable of the PLS analysis. The upper panel portrays the contrasts (brain scores) representing significant mean differences in ERP amplitude across outcomes and gamer status. The error bars represent the 95% confidence intervals from the bootstrap test. The bottom panel portrays the electrode saliences at three select electrodes and their respective scalp topography maps highlight the temporal and spatial distribution of the effects. The (o) above the x-axis indicate electrode saliences where the bootstrap ratio exceeded 2.5. In the topography maps, lighter colors reflect positive voltage and darker colors reflect negative voltage.

represents a smaller P2$_w$ and a quicker return to baseline for wins in the low and moderate gamers compared to the high gamers. Taken with the first latent variable, this may indicate that high doses of video game exposure are associated with decreased sensitivity to certain types of losses and increased sensitivity to rewards.

The fourth latent variable represented a contrast between busts and ties in the low gamers. This effect was not present in the moderate and high gamers (Figure 3.6). The electrode saliences reflected fairly stable neural activity across the epoch over the frontal-central region of the scalp.

Risk Task

Behavioral Data. The low gamers (*M* = .83, *SD* = .13) did not choose the low risk option significantly more often than the high gamers (*M* = .86, *SD* = .10), *t*(34) = -.76, *p* = .45. The low gamers (*M* = 417, *SD* = 600) did not end the game with significantly more points than the high gamers (*M* = 500, *SD* = 496), *t*(34) = -.46, *p* =

.65. The hypothesis that high gamers would be more risk-taking and make fewer points than the low gamers was not supported by the data.

ERP Data. Figure 3.7 shows the grand-averaged ERPs at select electrodes. The FRN appeared to be greater in amplitude for risky losses than for non-risky losses or either type of win in both low and high gamers. The amplitude of the $P2_w$ and P3 appeared to be greater for risky wins than for the other conditions. The data were analyzed in a set of 2 (gamer status: low, high) x 2 (outcome: win or lose) x 2 (risk: risky or non-risky) x 2, 3, or 4 (electrode) ANOVAs (see Method section). The

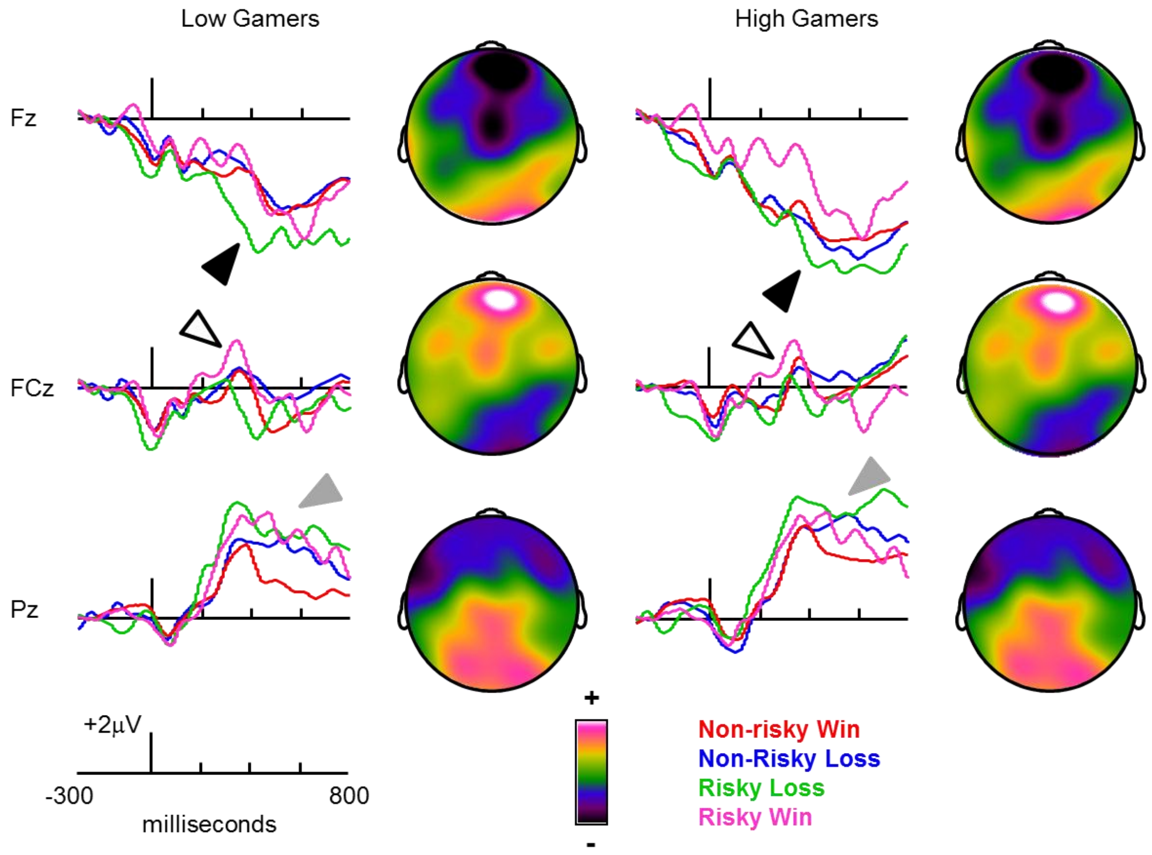

Figure 3.7. Top: Grand-averaged waveforms at Fz and topography maps (losses-wins) illustrating the FRN (black arrows). Middle: Grand-averaged waveforms at FCz and topography maps (wins-losses) illustrating the P2w (white arrow). Bottom: Grand-averaged waveforms at Pz and topography maps (risky-non-risky) illustrating the P3 (gray arrows). The tall bar represents stimulus onset, the short bars represent 200 ms increments, and positive is plotted up.

FRN was greater in amplitude for losses ($M = -2.64$ μV, $SD = 3.85$) than for wins ($M = -1.32$ μV, $SD = 3.82$), $F(1, 34) = 13.02$, $p = .001$, $\eta_p^2 = .28$. The risk x outcome interaction was significant, $F(1, 34) = 18.12$, $p = .001$, $\eta_p^2 = .35$. Post hoc analyses revealed that non-risky losses ($M = -1.89$ μV, $SD = 3.27$) did not differ significantly from non-risky wins ($M = -1.87$ μV, $SD = 3.22$), $F < 1$, $p = .93$; the amplitude of the FRN was significantly greater for risky losses ($M = -3.39$ μV, $SD = 5.22$) than for risky wins ($M = -.77$ μV, $SD = 5.23$), $F(1, 34) = 17.48$, $p = .001$, $\eta_p^2 = .34$. None of the interactions with gamer status were significant, F's < 1.0, p's > .51. The data are consistent with past research indicated that the FRN is greater in amplitude for losses than wins (Hajcak et al., 2005, 2006) and is modulated by the probability of the outcome (Holroyd et al., 2003). Gamer status does not seem to influence the amplitude of the FRN.

For the P2$_{\mathrm{w}}$, the main effect of outcome was significant, $F(1, 34) = 5.40$, $p = .03$, $\eta_p^2 = .14$, reflecting greater amplitude for wins ($M = .49$ μV, $SD = 3.12$) than for losses ($M = -.44$ μV, $SD = 3.55$). The risk x outcome interaction was significant, $F(1, 34) = 12.40$, $p = .001$, $\eta_p^2 = .27$. Further analysis revealed that losses were not significantly different for non-risky ($M = -.18$ μV, $SD = 2.88$) and risky ($M = -.70$ μV, $SD = 4.91$) trials, $F(1, 34) = .68$, $p = .42$, $\eta_p^2 = .02$. For wins, the P2$_{\mathrm{w}}$ was greater in amplitude on risky ($M = 1.45$ μV, $SD = 4.33$) than non-risky trials ($M = -.48$ μV, $SD = 3.00$), $F(1, 34) = 7.84$, $p = .01$, $\eta_p^2 = .19$. None of the interactions with gamer status were significant, F's < 1.0, p's > .44. The data are consistent with past studies demonstrating the P2$_{\mathrm{w}}$ is greater in amplitude for wins than losses, and is particularly sensitive to unexpected wins (Hewig et al., 2010), and this does not appear to be influenced by gamer status.

For the P3, the main effect of risk was significant, $F(1, 34) = 17.15$, $p = .001$, $\eta_p^2 = .34$, with the amplitude being greater for risky trials ($M = 4.94$ μV, $SD = 4.47$) than for non-risky trials ($M = 3.00$ μV, $SD = 4.26$). The risk x outcome interaction was also significant, $F(1, 34) = 14.03$, $p = .001$, $\eta_p^2 = .29$. Post hoc analyses revealed that for non-risky trials, the amplitude of the P3 was greater for losses ($M = 3.77$ μV, $SD = 4.66$) than for wins ($M = 2.24$ μV, $SD = 4.16$), $F(1, 34) = 15.47$, $p = .001$, $\eta_p^2 = .31$. In contrast, on risky trials, the P3 was greater in amplitude for wins ($M = 5.85$ μV, $SD = 5.80$) than for losses ($M = 4.03$ μV, $SD = 3.78$), $F(1, 34) = 7.65$, $p = .01$, $\eta_p^2 = .18$. This demonstrates that the P3 is sensitive to expectancy, being greater for the unexpected outcome on a given trial (i.e., on non-risky trials a loss is unexpected, but on risky trials a win is unexpected). None of the interactions with group were significant, F's < 2.31, p's > .14.

Probabilistic Selection

Behavioral Data. Sensitivity to positive and negative feedback was assessed by analyzing the proportion of trials on which A was selected or B was avoided during the test trials. The low gamers ($M = .66$, $SD = .26$) and high gamers ($M = .70$, $SD = .20$) did not significantly differ in their sensitivity to positive feedback, $t(48) = -.73$, $p = .47$. The high gamers ($M = .71$, $SD = .23$) were more sensitive to negative feedback than the low gamers ($M = .56$, $SD = .20$), $t(48) = -2.51$, $p = .02$, in contrast to the negative association found between hours and sensitivity to negative feedback in Study 1.

ERP Data. The grand-averaged ERPs at select electrodes are shown in Figure 3.8. The FRN was greater in amplitude for incorrect trials than for correct trials and the difference between correct and incorrect trials appeared larger in the high gamers than the low gamers. The amplitude of the P3 appeared to be greater for correct than incorrect trials in the low gamers, and in the high gamers, this difference appeared to be attenuated. The data were analyzed in a 2 (gamer status) x 2 (outcome: correct or incorrect) x 3 (pair: AB, CD, EF) ANOVA for the FRN and a 2 (gamer status) x 2 (outcome: correct or incorrect) x 3 (pair: AB, CD, EF) x 3

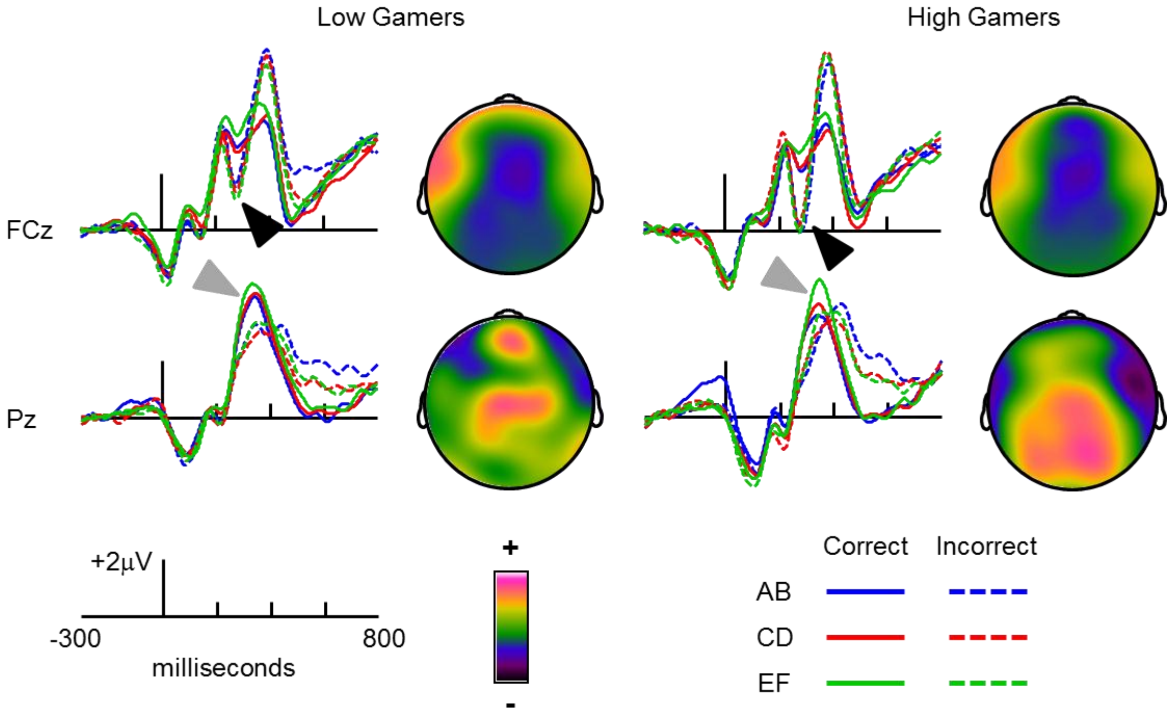

Figure 3.8. Top: Grand-averaged waveforms at FCz and topography maps (incorrect-correct) illustrating the FRN (black arrows). Bottom: Grand-averaged waveforms at Pz and topography maps (EF-AB) illustrating the P3 (gray arrows). The tall bar represents stimulus onset, the short bars represent 250 ms increments, and positive is plotted up.

(electrode: P3, Pz, P4) ANOVA for the P3. As a refresher, the probability of correct and incorrect feedback varies in each pair. In the AB pair, A is correct 80% of the time, in the CD pair, C is correct 70% of the time, and in the EF pair, E is correct 60% of the time.

The amplitude of the FRN was greater for incorrect trials (*M* = 1.14 μV, *SD* = 2.80) than for correct trials (*M* = 2.98 μV, *SD* = 2.93), *F*(1, 48) = 46.41, *p* = .0001, η_p^2 = .49. The pair x feedback interaction was significant, *F*(2, 96) = 3.00, *p* = .05, η_p^2 = .10. Further analysis revealed that the FRN was greater in amplitude for incorrect trials in the EF pair (Figure 3.9), than for the AB or CD pairs, which may reflect greater uncertainty about the correct figure in the EF pair. The main effect of pair and the interactions with gamer status were not significant, *F*'s < 1.17, *p*'s > .31.

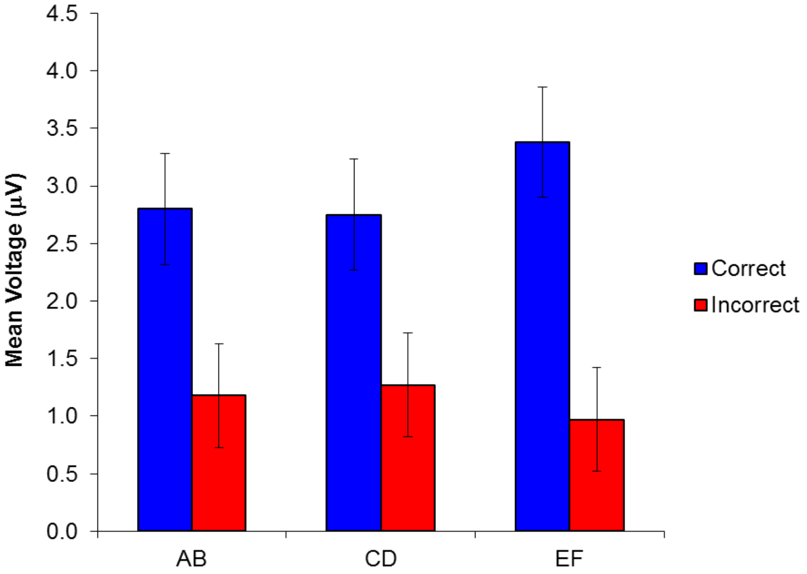

Figure 3.9. Mean amplitude of the FRN for the pair by feedback interaction. The difference between correct and incorrect trials is greater in the EF pair than the AB or CD pairs, likely reflecting the greater difficulty of using the feedback to learn about this pair. Error bars represent the standard error of the mean.

For the P3, the main effect of pair was significant, *F*(2, 96) = 3.99, *p* = .02, η_p^2 = .10. Further analysis revealed no difference in amplitude for the AB (*M* = .70 μV, *SD* = 2.86) and CD (*M* = .80 μV, *SD* = 2.55) pairs, $F(1, 48) < 1$, $p = .71$, $\eta_p^2 = .003$. The amplitude of the P3 was greater for the EF pair (*M* = 1.17 μV, *SD* = 2.53) than for the CD pair, $F(2, 96) = 6.78$, $p = .01$, $\eta_p^2 = .12$. As with the FRN, this likely reflects the added difficulty of learning about this pair given that the feedback is almost random. The gamer status x feedback interaction was significant, $F(1, 48) = 6.54$, $p = .01$, $\eta_p^2 = .12$ (Figure 3.10). The amplitude of the P3 was greater for correct choices than for incorrect choices in the low gamers; the highs gamers displayed the opposite pattern, although the difference did not reach statistical significance in either group. The main effect of feedback and all other interactions with group were not significant, *F*'s < 1, *p*'s > .46.

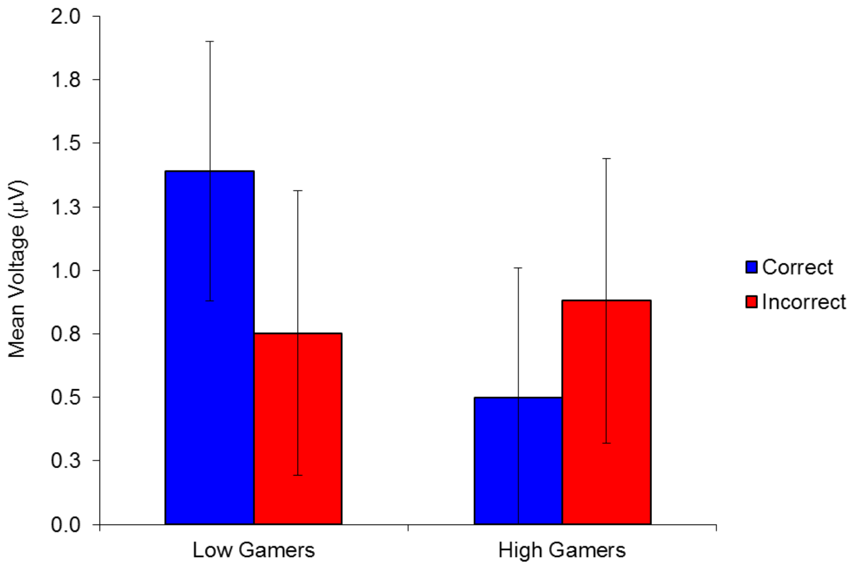

Figure 3.10. Mean amplitude of the P3 for the gamer status by feedback interaction. For low gamers, correct trials elicit a greater P3. For the high gamers, the incorrect trials elicit a greater P3, reflecting differences in the sensitivity to positive and negative outcomes. Error bars represent the standard error of the mean.

Discussion

The goal of Study 2 was to examine the relationship between individual differences in exposure to action video games and the neural correlates of feedback sensitivity and cognitive control in tasks that require decision making under risk.

Participants completed the UFOV task in order to demonstrate that the high gamers in the current study were similar to the action gamers in studies of visuospatial processing (Green & Bavalier, 2003; Dye et al., 2009). I predicted that the high gamers would be more accurate on this task, and the data supported this hypothesis. In the blackjack task, I hypothesized that moderate to high levels of video game experience would be associated with attenuation of the FRN and P3 for busts and losses, which would indicate a reduction in sensitivity to negative outcomes. The amplitude of the P3 over the central-parietal region was attenuated in the moderate and high gamers relative to the low gamers, and the first and second latent variables of the PLS analysis provided further evidence of a reduction in sensitivity to negative outcomes among video game players. In the risk task, I hypothesized that the high gamers would engage in riskier behavior demonstrated by greater selection of the risky options, lower final scores, and attenuation of the FRN and P3 for losses. Gamer status was not associated with changes in any of these variables. Finally, in the probabilistic selection task I hypothesized that high gamers would be less sensitive to negative feedback than low gamers and this would be reflected in decreased avoidance of B and attenuation of the FRN and P3 to negative feedback. The data actually revealed the opposite pattern, demonstrating increased sensitivity to negative feedback among high gamers in the behavioral and ERP data.

Study 1 revealed that screen time was associated with less avoidance of B in the probabilistic selection task, reduced selection of the low risk options in the risk task, and continued selection from the “bad” decks in the IGT, all indicating reduced sensitivity to negative outcomes. Consistent with this idea, the current study found that the neural response to negative outcomes (i.e., busts, losses) in the blackjack task was attenuated in moderate and high gamers, which reflects reduced sensitivity to these outcomes. A number of studies have demonstrated that violent content in certain genres of video games is associated with desensitization to violence (Engelhardt et al., 2011; Bailey et al., 2011; Bushman & Anderson, 2009; Bartholow et al., 2006), but violent content does not adequately explain why individuals exposed to first-person shooter video games would be less responsive to negative outcomes resulting from their own choices, particularly when those choices negatively impact their performance as in Study 1.

The reinforcement schedule of a typical first-person shooter video game may provide some insight into why gamers are less sensitive to negative outcomes. Failure in a first-person shooter video game means dying which usually results in replaying that segment of the game. While the player may find this frustrating, it in no way limits their ability to successfully beat the game so long as they keep playing (Rogers, 2010; Thompson, Berbank-Green, Cusworth, 2007). Video games are an environment where failure has virtually no long-term consequences and thus little need for the individual to pay much attention to mistakes. Generalized to decision-making outside of the game, it is not unsurprising that these individuals would be less sensitive to negative outcomes relative to non-gamers.

The high gamers in the current study did not display riskier decision making in the risk task compared to the low gamers. The amplitude of the ERPs were sensitive to outcomes, particularly unexpected outcomes (e.g., winning when the riskier option was chosen), but these effects were not moderated by gamer status. The current study recruited high gamers who played predominantly first-person shooter video games because these represent the action gamers used in other studies (Bailey et al., 2011, 2010; Green & Bavelier, 2003). The failure to find the expected differences between high and low gamers may speak to the importance of the interactions between screen time, pathology, and genre. Study 1 revealed an association between screen time and the interaction between screen time and number of pathological symptoms with performance in the risk task. Isolation of one genre in addition to limited numbers of pathological symptoms may reduce the predictive power of screen time. In fact, pathology may be a more important factor for understanding the consequences of gaming than hours or genre (or violent content) alone (Gentile et al., 2011; Gentile, 2009). Pathological video game use is a recent concept, so this is one fruitful avenue for future research.

In the probabilistic selection task, there was no significant effect of gamer status on sensitivity to positive feedback, consistent with Study 1. In contrast to Study 1, the high gamers were significantly more likely to avoid B than the low gamers, suggesting that the gamers were more sensitive to negative feedback in later decision making. During the learning phase of the task, the amplitude of the P3 was greater for incorrect than correct trials for the high gamers, providing further evidence of increased sensitivity to negative feedback. The latter finding is in direct conflict with the blackjack data in the current study, where individuals with more video game experience displayed reduced P3 amplitude to negative outcomes.

The reinforcement schedules in first-person shooter video games may again provide some explanation for the disparity between the blackjack and probabilistic selection data. Video games are structured environments with rules of gameplay that the individual must learn in order to be successful (Rogers, 2010). When a player picks up a new game or plays a particularly challenging one, he may find it difficult to learn the mechanics of the game resulting in frequent deaths and growing frustration. While he struggles to grasp the rules, negative feedback may be particularly salient (Gentile & Gentile, 2008; Thompson et al., 2007). Learning in the probabilistic selection task is slow, difficult, and frustrating (Frank et al., 2004), and it is exactly the type of environment in which action video game players may be the most sensitive to negative feedback.

An important limitation of the current study was that individuals were recruited based on their prior experience with video games, so the data are correlational and cannot be used to establish a causal relationship between gaming and differential neural activity while making decisions under risk. The groups did not differ significantly on the risk-attitudes scale or BIS-11, but there remains the possibility that some unmeasured variable accounts for the differences found in the current dataset.

The data for Study 2 provided mixed support for the hypothesis that gaming would be associated with risky behavior and reduced sensitivity to negative outcomes. The blackjack data indicated reduced sensitivity to negative feedback in gamers, while the probabilistic selection task indicated increased sensitivity to negative feedback among high gamers. The conflicting results emphasize the necessity for further research to understand the relationship between gaming and decision making. In particular, research that demonstrates a causal relationship between video game experience and changes in decision making or sensitivity to positive and negative outcomes is needed. Study 3 was designed to examine whether or not acute video game exposure could prime risky decision making and alter sensitivity to positive and negative feedback.

CHAPTER 4. STUDY 3

Study 1 established that video game experience, or screen time, predicted greater impulsivity, more positive attitudes towards risky behaviors, greater risk-taking, and decreased sensitivity to negative feedback. In Study 2, individuals with high levels of video game experience were associated with decreased sensitivity to negative feedback in the blackjack task and increased sensitivity to negative feedback in the probabilistic selection task as indexed by changes in the amplitude of the P3 relative to individuals with little video game experience. The conflicting results emphasize the complexity of the relationship between video game experience and risky decision making. The previous two studies were not designed to determine the extent to which exposure to video games causes changes feedback sensitivity and decision making under risk. Gaming experience was not experimentally manipulated, and while gaming had some predictive power in Study 1, there could easily be some unaccounted for variable that explains the findings. In order to determine causality, Study 3 was designed to investigate the effect of short-term exposure to video games on performance in the risk task and the probabilistic selection task.

Several studies have demonstrated short-term effects of video games on aggression (see Anderson et al., 2010 for review); recently, there has also been evidence that exposure to racing video games primed more positive attitudes/behavior towards risky driving (Fischer et al., 2007, 2009). Research examining video games and aggression usually have the participants play either a violent or nonviolent video game for 15 to 20 minutes and then complete a task that measures physiological arousal toward violence (Carnagey et al., 2007), aggressive behavior (Anderson et al., 2008), or helping behavior (Bushman & Anderson, 2009). Regardless of the measure used, participants exposed to the violent video game display decreased physiological arousal to violence, increased aggressive behavior, and decreased likelihood of offering help to a victim of violence (Anderson et al., 2010). These data suggest that even a very small amount of exposure to some genres of video games can prime changes in physiological and behavioral responses to violence.

Recent work demonstrating short-term exposure to racing video games increases positive attitudes, thoughts, and behaviors related to risky driving (Fischer et al., 2007, 2009) are particularly relevant to Study 3. Participants who played a racing video game for 20 minutes had greater accessibility of risk-related thoughts, greater levels of excitement and arousal, and longer reaction times to stop a risky driving maneuver than participants who played a control video game. This data indicate that risk-taking in one genre of video game can transfer to similar behavior outside of the game, but the effects of other genres of video games or on other domains of risky decision making is unclear. For instance, action gamers may be more likely to respond to situations in the moment rather than pre-planning their actions (Bailey et al., 2010) and if transferred to decision making in domains with serious consequences for the individual (e.g., gambling, substance use, social interactions), then it could be detrimental to their ability to avoid options that seem more appealing now, but have greater risks in the long-term.

The goal of Study 3 was to apply the paradigm described above to examine short-term effects of video games on decision making, thus extending the findings of Study 1 by demonstrating a causal relationship between video game exposure and changes in risk-taking and sensitivity to feedback. As in Study 1 and 2, the risk task and the probabilistic selection task were used to examine risky decision making and sensitivity to feedback, respectively. Participants in the current study played a racing, first-person shooter, or puzzle video game for 20 minutes before completing the tasks. For the risk task, I hypothesized that individuals who played one of the racing or first-person shooter video games would select the non-risky options less often and have lower final scores than the individuals who played a puzzle game. In the probabilistic selection task, I hypothesized that racing and first-person shooter video games would prime less avoidance of B indicating reduced sensitivity to negative feedback relative to the puzzle video games. The games were not expected to have differential effects on selections of A (i.e., sensitivity to positive feedback).

Method

Participants

Two hundred and seventy-two undergraduate students (82 female) from Iowa State University between the ages of 18 and 33 years participated in the study. Students taking Introduction to Psychology, Social Psychology, and Developmental Psychology could sign up for the study online. Individuals were randomly assigned to play a video game representing one of three different genres (first-person shooter, 89; racing, 93; puzzle, 90). The groups were not significantly different in age (*F*(2,

270) = 2.44, *p* = .09), sex (χ^2(2, *N* = 272) = .37, *p* = .83), or amount of previous video game experience (*F*(2, 270) = 1.30, *p* = .27; see Table 4.1 for means).

Materials and Design

Questionnaires. The media usage questionnaire was administered to assess video game experience (*coefficient α* = .77). Participants also completed the RAS (*coefficient α* = .84) and the BIS-11 (*coefficient α* = .79). These measures were identical to those used in Studies 1 and 2. A video game evaluation sheet was also administered to assess the participants' perception of the video games on 14 dimensions (e.g., violence, arousal, action; Appendix E; *coefficient α* = .78).

Video Games. The video games were chosen based on their use in previous research examining visuospatial processing (Feng et al., 2007; Green & Bavelier, 2006), aggression (Sestir & Bartholow, 2010; Carnagey et al., 2007) and prosocial behavior (Bushman & Anderson, 2009), and attitudes towards risky driving. Two of the video games were chosen to represent the violent/first-person shooter genre (FPS; *Unreal Tournament 3, Medal of Honor: Allied Assault)*. *Unreal Tournament 3* is a first-person shooter video game in which the player is tasked with killing computer opponents while trying to avoid being killed. Participants played the game's "Deathmatch" mode against 5 computer opponents on the Arsenal map. The kill/death ratio was recorded at the end of the 20 minutes. *Medal of Honor: Allied Assault* is a first-person shooter video game where the player takes on the role of a lieutenant in the United States Army during World War II. The main objective of the first level is to terminate as many enemy soldiers as possible without being killed. The kill/death ratio was recorded at the end of the 20 minutes.

In order to expand the findings of Fischer et al. (2007), two racing video games were included (Racing; *Need for Speed: Hot Pursuit, Carmageddon: Carpocalypse Now*). *Need for Speed: Hot Pursuit* was designed to provide players with cop versus racer chases. Participants played as a racer and tried to stay ahead of the police for the duration of the race. Their score and placement in the race were recorded after the 20 minutes. *Carmageddon* is a third-person driving game that allows players to control a vehicle to compete against computer opponents. The player can win by completing the track in the allotted time, disabling the other drivers, or killing all of the pedestrians in the level. Participants were instructed to gain as many points as possible and that the game awards more points for killing opponents and pedestrians. The high score was recorded after the game was played.

The remaining two video games were selected as nonviolent/nonaction control games (Puzzle; *Ballance, Zuma*) and represented the puzzle genre. In *Ballance*, players guide a ball through a floating maze without letting it fall. The mazes increase in difficulty and participants were instructed to complete as many as possible in the 20 minutes. In *Zuma*, players destroy colorful balls before they reach the end of a preset path by shooting balls of the same color at the path. For *Ballance* and *Zuma*, a score was recorded for each level of the game the participant was able to complete successfully by the end of the 20 minutes.

Tasks. The stimuli and design of the risk task and the probabilistic selection task were identical to Studies 1 and 2.

Procedure

All task stimuli were presented using the E-Prime 1.2 Software (Psychology Software Tools, Pittsburgh, PA). Informed consent was obtained, and participants completed the media usage questionnaire, RAS, and BIS-11. Participants then played a video game for 20 minutes. At the end of that time, half of the participants performed the probabilistic selection task followed by the risk task, and the remaining participants completed the tasks in the opposite order. After the tasks were completed, participants completed the video game evaluation scale, were debriefed, and thanked for their participation. The entire study took approximately 50 minutes.

Results

The goal of Study 3 was to prime risk taking and reduced sensitivity to negative feedback by exposing individuals to a first-person shooter or a racing video game for 20 minutes. FPS, Racing, and Puzzle groups did not differ significantly on attitudes towards risk, *F*(2, 270) = .59, *p* = .55, or impulsivity, *F*(2, 270) = .41, *p* = .67, measured before playing the game (Table 4.1). These measures were not correlated with any of the independent or dependent variables of interest, and where therefore not included in further analysis (Table 4.2).

Table 4.1. Psychometric Data for Study 3.

	Racing		FPS		Puzzle	
	M	*SD*	*M*	*SD*	*M*	*SD*
Age	19.57	2.23	19.09	1.26	19.70	2.14
Hours	15.94	15.66	19.10	16.09	19.51	17.52
BIS-11	64.72	9.21	63.61	9.44	64.61	8.72
RAS	2.25	0.55	2.19	0.48	2.17	0.53
	Males	Females	Males	Females	Males	Females
Sex	66	27	60	29	64	26

Table 4.2. Correlation Matrix with All Independent and Dependent Variables.

	Genre	BIS-11	RAS	Low Risk	Risk Total	Select A
BIS-11	-0.01					
RAS	-0.06	**0.30**				
Low Risk	0.06	-0.13	-0.11			
Risk Total	0.04	-0.09	-0.11	**0.90**		
Select A	-0.03	0.07	0.07	0.05	0.08	
Avoid B	-0.01	-0.11	0.07	0.02	0.00	-0.06

p < .05.

A MANOVA was conducted for the video game evaluation scale. The analysis revealed that the three video game genres differed on all 14 items (Table 4.3a). Rather than including each item as a covariate, principal components analysis (PCA) was performed on the scale. The initial eigenvalues revealed that the first component accounted for 49% of the variance, the second component accounted for 15% of the variance, and the third component accounted for 9% of the variance. The remaining components had eigenvalues of less than 1. A three component solution explained 72% of the variance after varimax rotation. All of the items had primary component loadings over .60 (Table 4.3b). The majority of the items loaded on the first component that reflected excitement/arousal. Two of the items had primary loadings on the second component that reflected difficulty. The third component was also comprised of two items and reflected violence/action. The results of the analyses were similar when one, two, or three of the components were included as covariates. Given the small amount of variance explained by the second and third components, the analyses reported below use only the first component as a covariate.

Table 4.3. a) Mean Ratings on the Video Game Evaluation Scale b) PCA Item Loadings.

	a) Racing	FPS	Puzzle		b)		
	M	*M*	*M*	*F**	1st Component	2nd Component	3rd Component
1. The game was action packed.	4.04	5.02	2.52	63.39	0.33	0.04	**0.84**
2. The game was entertaining.	4.01	4.80	5.13	11.04	**0.89**	-0.22	0.002
3. The game was exciting.	3.75	4.53	4.00	5.45	**0.83**	-0.08	0.28
4. The game was frustrating.	4.72	3.36	3.54	16.79	-0.001	**0.85**	-0.03
5. The game was fun.	3.73	4.64	5.11	19.61	**0.86**	-0.28	-0.11
6. The game was boring.	3.84	2.99	2.82	9.83	**-0.71**	0.29	-0.05
7. The game was violent.	4.22	4.82	1.19	158.45	-0.22	0.14	**0.85**
8. The game was difficult to play.	4.80	2.81	2.09	73.11	-0.08	**0.82**	0.23
9. The game was absorbing.	3.53	3.99	4.07	3.07	**0.77**	0.20	0.002
10. The game was arousing.	2.83	3.56	2.89	5.75	**0.65**	0.14	0.27
11. The game was enjoyable.	3.70	4.62	4.97	15.00	**0.88**	-0.24	-0.07
12. The game was involving.	3.68	4.28	4.36	4.85	**0.84**	0.08	0.03
13. The game was stimulating.	3.66	4.31	4.29	4.67	**0.83**	0.02	0.11
14. The game was addicting.	3.13	3.49	4.38	10.72	**0.78**	0.07	-0.16

*All tests significant at p < .05.
Component loading >.60.

Risk Task. The dependent variables for the risk task were the percentage of trials where the low risk option was selected and the final score at the end of the task. The means for both of these variables were in the hypothesized direction, with Racing selecting the low risk options least often and ending the game with the fewest points, followed by FPS, then Puzzle (Figure 4.1). The covariates were not significant for either variable, *F*'s < 1.0, *p*'s > .85. The effect of video game genre on the proportion of trials on which the low risk option was selected was not significant, *F*(2, 269) = .83, *p* = .44, η_p^2 = .01 (Figure 4.1a). The end score did not significantly differ across the genres, *F*(2, 269) = .55, *p* =

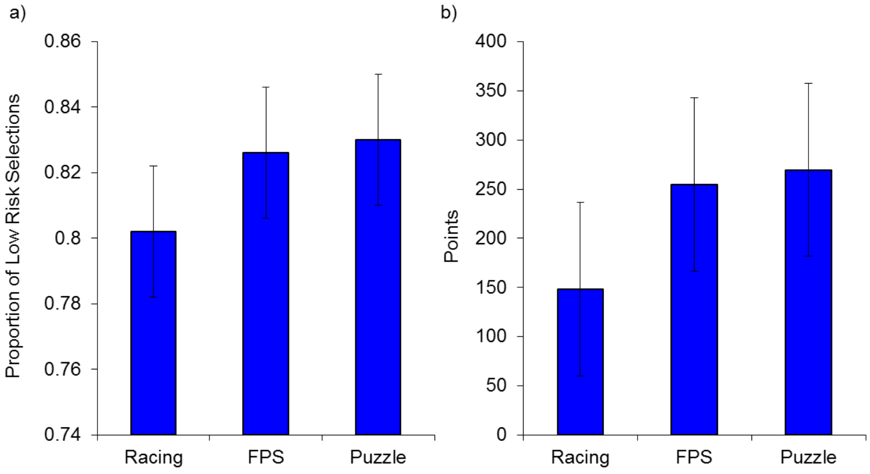

Figure 4.1. Results for the risk task. Individuals who played a racing video game made fewer low risk selections (a) and less points (a), but the difference was not statistically significant. Error bars represent the standard error of the mean.

.58, η_p^2 = .004 (Figure 4.1b), and the results did not differ significantly when the covariate was excluded. This indicates that playing a racing or FPS video game for 20 minutes did not significantly increase risk-taking, although the means were in the hypothesized direction.

Probabilistic Selection. The dependent variables for the probabilistic selection task were the proportion of trials were A was selected or B was avoided during the test phase, reflecting sensitivity to positive and negative outcomes, respectively. The means were in the hypothesized direction with FPS being more sensitive to positive and less sensitive to negative outcomes (Figure 4.2). The covariates were not significant for either variable, F's < 2.09, p's > .15. The genres did not differ significantly on the selections of A, $F(2, 269)$ = .15, p = .86, η_p^2 = .001, or avoidance of B, $F(2, 269)$ = .60, p = .55, η_p^2 = .004. The results did not differ significantly when the covariate was excluded. The data did not support the hypothesis that playing a racing or FPS video game would prime reduced sensitivity to negative outcomes.

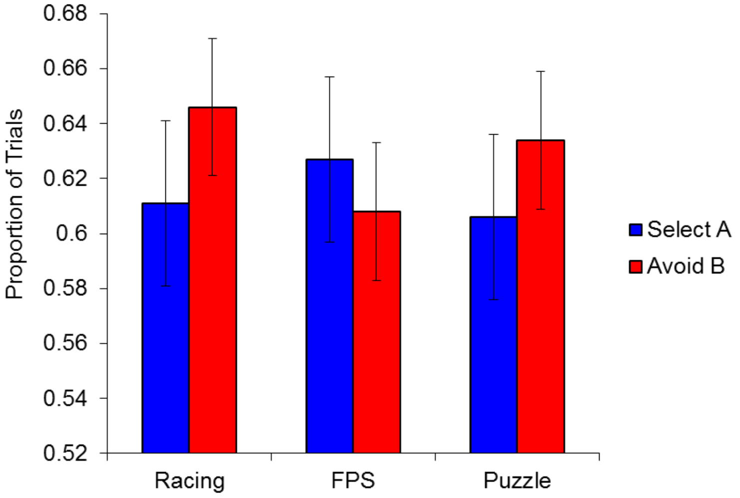

Figure 4.2. Results for the probabilistic selection task. Individuals who played a FPS game avoided B less, but the difference was not statistically significant. Error bars represent the standard error of the mean.

Discussion

The purpose of Study 3 was to demonstrate a causal link between short-term exposure to video games and risky decision making. It was hypothesized that racing and first-person shooter video games would prime riskier decisions and reduced sensitivity to negative feedback in comparison to puzzle video games. While the data generally trended in the hypothesized direction, there were no significant effects of video game on any of the dependent variables, even after controlling for differences in how engaging participants found the games.

The design of the current study was largely based on past research that indicated as little as 20 minutes of gaming could prime aggressive behavior (Anderson et al., 2010) and risky-driving behavior (Fischer et al., 2009). One difference between the current study and the studies on risky driving is the similarity between the video game and the task used to assess decision making. In Fischer et al., the participants played a racing video game and then performed the Vienna Driving test in which they watched a video of driving and pressed a button to stop the car in the video from executing a risky maneuver. The behavior assessed in the driving test was essentially the same behavior performed in the video game. In contrast, the current study exposed individuals to 20 minutes of three different genres of video games, none of which resembled the risk or probabilistic selection tasks. Although there is some evidence to suggest transfer of skill in other domains (Bailey & West, 2012; Dye et al., 2009), it is possible that for risky decision making, the behavior needs to be highly similar to the behaviors learned in the video game in order to influence performance. In other words, the effect of gaming on decision making may be domain-specific.

The current study may have failed to prime risky decision making because in most cases risk-aversion is the default behavior (Camerer & Weber, 1992; Kahneman & Tversky, 1992). In the current data from the risk task, over 5% of the participants never chose the risky option, and approximately 90% of the participants selected the non-risky option on the majority ($\geq$ 60%) of the trials, demonstrating a clear aversion to taking risks. There are fairly well-defined variables that affect when people will be risk-seeking (Weber, 2006; Read & Loewenstein, 1999; Tversky et al., 1990; Kahneman & Tversky, 1984). For instance, finding a behavior less aversive has been offered as one potential link between playing racing video games and riskier driving behavior (Fischer et al., 2007; Beullens et al., 2011), and short-term exposure to a racing video game does in fact decrease aversion to risky driving behavior and slow reaction times to stop risky driving maneuvers (Fischer et al., 2007, 2009). However, the participants did eventually stop the maneuver. This may indicate that video game exposure prolongs the decision making process, which may or may not result in the individual choosing to take the risk.

As discussed in Study 2, pathology and the interactions between pathology, screen time, and genre may be a more important factor than experience alone for determining how video games influence decision making. Pathological gamers do tend to be at a greater risk than non-pathological gamers for many negative outcomes (e.g., attention deficits, poor academic performance, more depressive symptoms; Gentile et al., 2011; Gentile, 2009). Greater need for reinforcement and focus on short-term outcomes might be the underlying factors driving changes in sensitivity to reward and punishment found in some video game users (see Study 1 and 2).

Finally, it could simply be that video game experience does not cause decreased sensitivity to negative outcomes or greater risky decision making, but rather that people who are more impulsive or risk-seeking tend to play more video games because gaming allows them to take extreme risks and rewards them for impulsiveness without any of the pesky consequences they would suffer in real-life. Impulsiveness and attention-deficits are predictive of greater use of video games and worse outcomes for pathology (Gentile et al., 2011). On the other hand, studies have also shown that video game use predicts an increased number and severity of symptoms (Swing et al., 2009; Gentile, 2009; Gentile et al., 2012). The reciprocal relationship between impulsivity, attention deficits, and increased gaming may influence decision making in ways not yet understood, which future research will hopefully shed light on.

CHAPTER 5. GENERAL DISCUSSION

The purpose of the current studies was to examine the association between video game experience and risky decision making. Study 1 established that screen time was related to differences in sensitivity to rewards, impulsivity and risk-taking; the data also indicated that pathological use and game genre may be important factors in determining how screen time relates to these variables. Study 2 revealed that individual differences in action video game experience were associated with differences in the neural correlates of processes related to the evaluation of positive and negative outcomes, and were not associated with differences in the initial (en)coding of the outcomes. Finally, Study 3 attempted to establish a causal relationship between video game experience and variation in risky decision making. While the data were consistent with my hypotheses, the differences between the genres of video games were not significant. Together, the data from these three studies lead to the suggestion that there is a relationship between video game experience and risky decision making; however, further research will be necessary to determine the causal direction of the relationship and expand upon our understanding of moderating variables. In the following pages, I discuss the implications of the current studies and describe possible directions for future research.

Consistent with my hypotheses, Study 1 found that screen time was associated with increased impulsivity as measured by the BIS-11 and reduced sensitivity to negative feedback as measured by the probabilistic selection task and the risk task. As noted previously, reduced sensitivity to negative outcomes may explain the continued selection of risky options among individuals with greater video game experience; as they are unlikely to use the feedback to guide their decisions if they are less sensitive to it (Bechara et al., 1994, 1996). This demonstrates that video game experience in general is associated with differences in risky decision making. The data revealed that some of the strongest associations involved risky decision making and the interactions between hours, genre, and pathological use. These relationships and their implications for future work on video games and risky decision making are explored below.

Game Genre: You are What You Play

Video game research has explored multiple genres of games, from fighting and adventure (Anderson et al., 2010), to first-person shooters and puzzles (Green et al., 2010), to real-time strategy (Basak et al., 2008). The General Learning Model (GLM) posits that repeated exposure to video games teaches individuals affective, behavioral, and cognitive scripts that may be applied to situations outside of the video game environment (Barlett & Anderson, 2012; Buckley & Anderson, 2006). In the GLM, each exposure to a video game can be thought of as a learning encounter in which the personal (e.g., cognition, affect, arousal) and situational (i.e., the surrounding environment) variables that the individual brings to the encounter interact with the content of the video game. Over multiple learning encounters, personality changes may occur. Consistent with the GLM, the data from the current set of studies indicates that video games may influence behavior in ways that reflect the game mechanics and reinforcement learning schedules typical of a given genre.

In Study 1, action video games (i.e., first-person shooters) were associated with greater impulsivity and riskier decision making than non-action games, and in Study 2 this genre were associated with decreased sensitivity to negative outcomes in the blackjack task. Overall success in a first-person shooter video game is only marginally hampered by death/incomplete mission objectives (e.g., save the hostages) because the player can restart the game at a previous point to correct their mistakes (Rogers, 2010; Thompson et al., 2007). Failure has virtually no long-term consequences in a first-person shooter, allowing the player to ignore it after the initial frustration has passed. As predicted by the GLM (Buckley & Anderson, 2006), generalizing the behaviors reinforced in a first-person shooter to decision-making outside of the game is likely to encourage impulsivity and less sensitivity to negative outcomes. This tendency is also consistent with the reliance on reactive cognitive control, rather than proactive, demonstrated in action gamers (Bailey et al., 2010).

In contrast to the findings of Study 1 and the blackjack task, Study 2 did not reveal group differences in the risk task, and revealed that action gamers were more sensitive to negative outcomes in the probabilistic selection task. This finding is close to what one might expect for strategy gamers, which was associated with lower impulsivity and greater sensitivity to negative outcomes in Study 1. Game mechanics and reinforcement learning schedules may provide an explanation for the differences observed for the two types of games. The nature of strategy video games, unlike action games, encourages careful planning and deferred gratification. Success is a culmination of all of the decisions made throughout the game, play usually spans a longer time frame than an action video game, and there are no restarts (Rogers, 2010; Thompson et al., 2007). In addition, strategy games tend to be played with others, so there are social implications for failure (Bennerstedt, Ivarsson, & Linderoth, 2012). Mistakes in a strategy video game can be costly, and learning how to avoid negative outcomes is essential for success.

Strategy video games are currently the most played genre (ESA, 2012), so it was difficult to recruit “pure” action gamers for Study 2. Compared to previous semesters where only 25% of gamers reported playing strategy games, in the current studies 45% of gamers reported playing games in this genre. Variation in the popularity of a particular genre is likely related to the release of highly anticipated video games. For example, *DC Universe*, an online strategy game, was released in January, 2011 (GameSpot, 2011) and has been free to play since November of the same year (Sony Online Entertainment, 2011). After the switch, the number of players went up 300% (PCGamer, 2011). Given the differential effects of action and strategy video games, it is difficult to tell what behavior would look like in a mixed sample. The importance of further investigation related to the additive or interactive effects of two or more game genres becomes evident when one considers that action and strategy video games represent two of the three best-selling game genres (ESA, 2012).

Study 3 failed to demonstrate a causal effect of playing a racing or first-person shooter video game on risky decision making, although the small mean differences were in the expected direction. Individuals were only exposed to a video game for 20 minutes, and none of the games resembled the risk task or probabilistic selection task. It is possible that the context of the decision needs to be highly similar to the video game environment in order to influence risk-taking. Consistent with this idea, previous work using racing video games found differences in decision making that were specific to risky driving attitudes and behaviors (Buellens et al., 2010; Fischer et al., 2009). The effect of gaming on decision making may be domain-specific, or differences in risky decision making may require longer exposure to take effect. Future research could address the latter issue in a training study using various different genres.

Video Games and the Neural Correlates of Negative Outcomes

Based upon the results of Study 1 it was not possible to determine at what point during the processing of consequences differential sensitivity to negative outcomes emerged. There are two possibilities that were considered given the ERP data from Study 2: 1) video game experience may influence the initial (en)coding of the outcome, or 2) video game experience may influence how the outcome is evaluated or categorized. The results of Study 2 suggest that gamer status was not associated with changes in the initial (en)coding of the outcome of a decision (FRN, $P2_w$), but was associated with differences in the evaluative categorization of the outcomes (P3).

In the blackjack task for example, the amplitude of the P3 was attenuated in the moderate and high gamers relative to the low gamers, and the first and second latent variables of the PLS analysis provided further evidence for a reduction in sensitivity to negative outcomes among video game players. This indicates that video game players encode losses, but negative outcomes may not be as motivationally significant to them in comparison to non-gamers (Bradley, 2009).

Reduced motivational significance of negative consequences provides an explanation for the riskier decision making found in Study 1.

In contrast to the findings for the blackjack task, the amplitude of the P3 for negative feedback was greater for high gamers than low gamers in the probabilistic selection task. One reason for the difference could be the difficulty of learning the rules in the probabilistic selection task. In an action video game, negative feedback may be more salient while the player is learning how to play, and then less so once they are familiar with the rules and game mechanics (Gentile & Gentile, 2008; Thompson et al., 2007). If the high gamers had not learned to consistently discriminate between the figures by the time they were tested, they might appear more sensitive to the negative feedback than the low gamers. I am currently extracting a more sensitive measure of learning from this data that might support this explanation.

Based on the ERP data for the blackjack task and probabilistic selection task, video game experience appears to be associated with differences in the evaluation of negative outcomes, rather than the initial coding of the outcome as good or bad. The differences in evaluative categorization of losses in the blackjack task and evidence that video game players are desensitized to violent images (Bailey et al., 2011; Engelhardt et al., 2011; Bartholow et al., 2006) indicates that video game experience may be associated with a general reduction in the motivational relevance of negative stimuli. An exception to this rule may be cases where the negative stimuli are particularly relevant to task performance, such as the learning phase in the probabilistic selection task, the detection of angry faces in a target detection task

(Bailey & West, 2012), and the assessment of threat level in a picture rating task (Bailey et al., 2011). These data demonstrate the role of situational variables in the application of scripts learned in a video game, consistent with the predictions of the GLM (Buckley & Anderson, 2006).

Pathological Gaming

In addition to screen time and game genre, pathological gaming emerged as an important factor in determining the relationship between gaming and risky decision making in Study 1, and may also have contributed to the failure to find significant group differences in Studies 2 and 3. Consistent with previous work (Gentile, 2009; Gentile et al., 2012; Gentile et al., 2011), the results of Study 1 revealed that gamers who reported a greater number of pathological symptoms were more impulsive. Greater impulsivity would be consistent with the idea that gamers often rely on reacting to a situation when it occurs rather than planning their actions in advance (Bailey et al., 2010; Mathews et al., 2005). Study 2 found no difference in self-reported impulsivity between low and high gamers, although this may not be surprising given that only one of the high gamers met criteria for pathological gaming. Based on Study 1 and previous work (Gentile, 2009), the percentage of the population who would be considered pathological gamers is relatively small (around 7 to 9%), therefore targeted recruitment of these individuals (or a very large sample as in Study 1) may be necessary to detect differences associated with pathological gaming.

Study 1 also revealed a positive relationship between pathological gaming, risky decision making, and sensitivity to feedback. Pathological gamers, particularly those who also reported more screen time, made riskier choices and continued to do so even after it became clear these choices were not advantageous (e.g., point totals fell into negative values). This suggests that these individuals were more willing to accept risk, but it does not immediately reveal why this would be the case. Evidence in the alcohol literature has demonstrated that individuals with a greater likelihood of becoming alcoholics reported less negative affect to errors on a task, suggesting that insensitivity to the negative consequences of their actions may be one pathway by which use of a substance becomes abuse (Bartholow, Henry, Lust, Saults, & Wood, 2012). The data from Study 1 indicate that this may also be true for pathological video game use, as pathology was related to reduced sensitivity to negative feedback. Further research will be essential for determining the role of differential sensitivity to feedback in the development of pathological behaviors (e.g., video game use, alcohol, gambling).

In contrast to Study 1, Study 2 did not reveal reduced sensitivity to negative feedback among the high gamers in the risk task or probabilistic selection task. Individuals were not recruited by pathological gaming status and this may have limited the ability to replicate the associations established in Study 1. Further analyses of this data that consider pathological symptoms are being conducted and preliminary results indicate that individuals with pathological symptoms do show evidence of reduced sensitivity to negative feedback (Bailey, 2012). Pathological gaming is a promising avenue for future research and this work will be essential for the identification of risk factors and development of successful interventions.

Summary

The data from the current studies provide some support for the hypothesis that exposure to video games is associated with differences in risky decision making outside of the gaming environment. Study 1 demonstrated a relationship between video game experience and differences in sensitivity to negative feedback and risky decisions that may vary by game genre and the presence of symptoms related to pathological gaming. Study 2 demonstrated that video game experience was associated with differences in the evaluative categorization of negative outcomes, providing a possible explanation for the behavioral differences identified in Study 1. Study 3 failed to establish a causal relationship between short-term exposure to video games and differences in risky decision making. These data indicate many possible directions for future research that could provide a better understanding of the relationship between video game experience and risky decision making. Further examination of game genre and pathological gaming may be particularly useful in determining when video game experience may be most strongly related to insensitivity to negative feedback and riskier decision making.

APPENDIX A. MEDIA USAGE QUESTIONNAIRE

On a typical <u>school day</u> (Monday through Friday), for how many <u>hours</u> do you <u>play video games</u> during each of the following times?

1. 6 AM – Noon _____
2. Noon - 6 PM _____
3. 6 PM – Midnight _____
4. Midnight - 6 AM _____

On a typical <u>weekend day</u> (Saturday or Sunday), for how many <u>hours</u> do you <u>play video games</u> during each of the following times?

5. 6 AM – Noon _____
6. Noon - 6 PM _____
7. 6 PM – Midnight _____
8. Midnight - 6 AM _____

How often do you play each of the following genres of video games?

1: I **never** play it
2: I **rarely** play it
3: I **occasionally** play it
4: I **sometimes** play it
5: I **often** play it
6: I **always** play it

9. _______ Sports (Madden NFL, NBA)
10. _______ Action/Adventure (Assassin's Creed, Prince of Persia, Tomb Raider)
11. _______ Puzzle Games (Super Monkey Ball, Bejeweled, Tetris)
12. _______ Fighting Games (Street Fighter IV, Soul Calibur, Mortal Kombat)
13. _______ First-person Shooters (Halo, Unreal Tournament, Call of Duty)
14. _______ Third-person Shooters (Gears of War, Grand Theft Auto)
15. _______ Strategy (Starcraft, Civilization)
16. _______ Simulation (Flight Simulator, Sim City)
17. _______ Music & Party (Dance Dance Revolution, Rock Band)
18. _______ Single-player Roleplaying Game (Diablo 2, Final Fantasy XII, Dragon Age)
19. _______ Real World Massively Multiplayer Online Game (Second Life)
20. _______ Massively Multiplayer Online Roleplaying Game (World of Warcraft, Guild Wars)

21. What video game do you play most often? _______________________

APPENDIX B. PATHOLOGICAL GAMING SCALE

Please answer the following questions by circling Y (yes), N (no), S (sometimes), or DK (don't know).

1. In the past year, have you played video games as a way of escaping from problems or bad feelings? Y N S DK

2. In the past year, have you become restless or irritable when attempting to cut down or stop playing video games? Y N S DK

3. In the past year, have you ever done poorly on a school assignment or test because you spent too much time playing video games? Y N S DK

4. In the past year, have you needed to spend more and more time and/or money on video games in order to achieve the desired excitement? Y N S DK

5. In the past year, have you become more preoccupied with playing video games, studying video game playing, or planning the next opportunity to play? Y N S DK

6. In the past year, have you ever lied to family or friends about how much you play video games? Y N S DK

7. In the past year, have you ever neglected household chores to spend more time playing video games? Y N S DK

8. In the past year, have you ever committed illegal/unsocial acts such as theft from family, friends, or elsewhere in order to get video games? Y N S DK

9. In the past year, have you ever needed friends or family to help you financially because you spent too much money on video game equipment, software, or game/Internet fees? Y N S DK

10. In the past year, have you often spent more money than you could afford on video games? Y N S DK

11. In the past year, has your work ever suffered (e.g., postponing things, missing deadlines, being too tired to function well, etc.) because you spent too much time playing video games? Y N S DK

12. Do you sometimes try to limit your own playing?

☐ Yes ☐ If yes, are you successful in limiting yourself? ☐ Yes

☐ No ☐ No

☐ Sometimes

APPENDIX C. BARRATT IMPULSIVENESS SCALE

DIRECTIONS: People differ in the ways they act and think in different situations. This is a test to measure some of the ways in which you act and think. Read each statement and put an X on the appropriate circle on the right side of this page. Do not spend too much time on any statement. Answer quickly and honestly.

O	O	O	O
Rarely/Never	Occasionally	Often	Almost Always/Always

1	I plan tasks carefully.	O	O	O	O
2	I do things without thinking.	O	O	O	O
3	I make-up my mind quickly.	O	O	O	O
4	I am happy-go-lucky.	O	O	O	O
5	I don’t “pay attention.”	O	O	O	O
6	I have “racing” thoughts.	O	O	O	O
7	I plan trips well ahead of time.	O	O	O	O
8	I am self controlled.	O	O	O	O
9	I concentrate easily.	O	O	O	O
10	I save regularly.	O	O	O	O
11	I “squirm” at plays or lectures.	O	O	O	O
12	I am a careful thinker.	O	O	O	O
13	I plan for job security.	O	O	O	O
14	I say things without thinking.	O	O	O	O
15	I like to think about complex problems.	O	O	O	O
16	I change jobs.	O	O	O	O
17	I act “on impulse.”	O	O	O	O
18	I get easily bored when solving thought problems.	O	O	O	O
19	I act on the spur of the moment.	O	O	O	O
20	I am a steady thinker.	O	O	O	O
21	I change residences.	O	O	O	O
22	I buy things on impulse.	O	O	O	O
23	I can only think about one thing at a time.	O	O	O	O
24	I change hobbies.	O	O	O	O
25	I spend or charge more than I earn.	O	O	O	O
26	I often have extraneous thoughts when thinking.	O	O	O	O
27	I am more interested in the present than the future.	O	O	O	O
28	I am restless at the theater or lectures.	O	O	O	O
29	I like puzzles.	O	O	O	O
30	I am future oriented.	O	O	O	O

APPENDIX D. RISK-ATTITUDES SCALE

For each of the following statements, please indicate your likelihood of engaging in each activity or behavior.
Provide a rating from 1 to 5, using the following scale:

1	**2**	**3**	**4**	**5**
Very unlikely	**Unlikely**	**Not sure**	**Likely**	**Very likely**

1. Going camping in the wilderness, beyond the civilization of a campground. (R) _______

2. Betting a day’s income at the horse races. (G) _______

3. Cheating on an exam. (E) _______

4. Chasing a tornado or hurricane by car to take dramatic photos. (R) _______

5. Cheating by a significant amount on your income tax return. (E) _______

6. Betting a day’s income at a high stake poker game. (G) _______

7. Having an affair with a married man or woman. (E) _______

8. Forging somebody’s signature. (E) _______

9. Passing off somebody else’s work as your own. (E) _______

10. Going on a vacation in a third-world country without prearranged travel and hotel accommodations. (R) _______

11. Going down a ski run that is beyond your ability or closed. (R) _______

12. Illegally copying a piece of software. (E) _______

13. Going whitewater rafting during rapid water flows in the spring. (R) _______

14. Betting a day’s income on the outcome of a sporting event (e.g. baseball, soccer, or football). (G) _______

15. Shoplifting a small item (e.g. a lipstick or a pen). (E) _______

16. Stealing an additional TV cable connection off the one you pay for. (E) _______

17. Periodically engaging in a dangerous sport (e.g. mountain climbing or sky diving). (R)_______

18. Gambling a week’s income at a casino. (G) _______

19. Trying out bungee jumping at least once. (R) _______

20. Piloting your own small plane, if you could. (R) _______

APPENDIX E. VIDEO GAME EVALUATION
VIDEO GAME EVALUATION

Game Name:______________________________ Game #:______ Subject ID:___________

Please answer the following questions about the video game you played today. To ensure confidentiality, please do not write your name or student ID on the sheet.

****

Please read each of the following statements and indicate your agreement with each (circle a number):

1. The game was action packed. Strongly Disagree: 1 2 3 4 5 6 7 :Strongly Agree
2. The game was entertaining. Strongly Disagree: 1 2 3 4 5 6 7 :Strongly Agree
3. The game was exciting. Strongly Disagree: 1 2 3 4 5 6 7 :Strongly Agree
4. The game was frustrating. Strongly Disagree: 1 2 3 4 5 6 7 :Strongly Agree
5. The game was fun. Strongly Disagree: 1 2 3 4 5 6 7 :Strongly Agree
6. The game was boring. Strongly Disagree: 1 2 3 4 5 6 7 :Strongly Agree
7. The game was violent. Strongly Disagree: 1 2 3 4 5 6 7 :Strongly Agree
8. The game was difficult to play. Strongly Disagree: 1 2 3 4 5 6 7 :Strongly Agree
9. The game was absorbing. Strongly Disagree: 1 2 3 4 5 6 7 :Strongly Agree
10. The game was arousing. Strongly Disagree: 1 2 3 4 5 6 7 :Strongly Agree
11. The game was enjoyable. Strongly Disagree: 1 2 3 4 5 6 7 :Strongly Agree
12. The game was involving. Strongly Disagree: 1 2 3 4 5 6 7 :Strongly Agree
13. The game was stimulating. Strongly Disagree: 1 2 3 4 5 6 7 :Strongly Agree
14. The game was addicting. Strongly Disagree: 1 2 3 4 5 6 7 :Strongly Agree

****

Have you played this video game before? (circle one) YES NO

APPENDIX F. BRIEF HANDEDNESS INVENTORY

Participant ID#: ______________

Have you ever had any tendency to left-handedness? YES NO

Please indicate your preferences in the use of hands in the following activities by putting + in the appropriate column. Where the preference is so strong that you would never try to use the other hand unless absolutely forced to, put ++. If in any case you are really indifferent, put + in both columns.

Some of the activities require both hands. In these cases, the part of the task or object, for which hand-preferences is wanted is indicated in brackets.

Please try to answer all the questions, and only leave a blank if you have no experience at all with the object or task.

	Right	**Left**
1. Writing	________	________
2. Drawing	________	________
3. Throwing	________	________
4. Scissors	________	________
5. Toothbrush	________	________
6. Knife (without fork)	________	________
7. Spoon	________	________
8. Broom (upper hand)	________	________
9. Striking Match (match)	________	________
10. Opening Box	________	________
Total	________	________

APPENDIX G. INFORMED CONSENT DOCUMENTS

INFORMED CONSENT DOCUMENT

Title of Study:	**Decision Making and Media**
Investigators:	Robert West, Kira Bailey, Brandy Tiernan, Ashley Scolaro, Brandt Uitermarkt, Cassandra Anglade, Michelle Farrington, Judson Kuffel, Justin Rhode, Mollie Tiernan, Emmanuel Ukpan

This is a research study. Please take your time in deciding if you would like to participate. Please feel free to ask questions at any time.

INTRODUCTION

The purpose of this study is to examine cognitive processes involved in decision making. You are eligible to participate in this project as part of the Department of Psychology Research participation pool. As noted on your course syllabus, participation in experiments is one of the available options for acquiring experimental credit in your psychology course.

DESCRIPTION OF PROCEDURES

If you agree to participate, you will be asked to complete 5 brief questionnaires measuring emotion, media usage, and decision making. You will also complete 8 tasks on the computer which will measure attention and decision making. These tasks will be explained and any questions you have will be answered. The entire experiment should take approximately 120 minutes.

RISKS

There are no known risks associated with performing the computer tasks. Stimuli will be cards, shapes, or words.

BENEFITS

If you decide to participate in this study there will be no direct benefit to you. It is hoped that the information gained in this study will benefit society by extending our understanding of the relationship between prior video game experience, attention, and decision making.

ALTERNATIVES TO PARTICIPATION

Alternatives other than research participation for earning research/extra credit are described in your course syllabus.

COSTS AND COMPENSATION

You will not have any costs from participating in this study. You will be compensated for participating in this study by earning 3 course credits.

PARTICIPANT RIGHTS

Your participation in this study is completely voluntary and you may refuse to participate or leave the study at any time. If you decide to not participate in the study or leave the study early, it will not result in any penalty or loss of benefits to which you are otherwise entitled. You can skip any questions that you do not wish to answer.

CONFIDENTIALITY

Records identifying participants will be kept confidential to the extent permitted by applicable laws and regulations and will not be made publicly available. However, federal government regulatory agencies auditing departments of Iowa State University, and the Institutional Review Board (a committee that reviews and approves human subject research studies) may inspect and/or copy your records for quality assurance and data analysis. These records may contain private information. We are required by the University IRB to keep a copy of the informed consent.

To ensure confidentiality to the extent permitted by law, the following measures will be taken: The electronic data will be stored on a password-protected computer that is in the experimenters' laboratory. Only the investigators have access to this computer. The consent form will be separated from the other data following the completion of data collection and maintained in a locked file cabinet so that there is no way to link the identity of the individual to the written or electronic data. The data collected in this research will be used for scientific purposes and may be presented at scientific meetings or published in professional journals. If the results are published, your identity will remain confidential.

QUESTIONS OR PROBLEMS

You are encouraged to ask questions at any time during this study.

- For further information about the study contact Dr. Robert West, rwest@iastate.edu.
- If you have any questions about the rights of research subjects or research-related injury, please contact the IRB Administrator, (515) 294-4566, IRB@iastate.edu, or Director, (515) 294-3115, Office for Responsible Research, Iowa State University, Ames, Iowa 50011.

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PARTICIPANT SIGNATURE

Your signature indicates that you voluntarily agree to participate in this study, that the study has been explained to you, that you have been given the time to read the document, and that your questions have been satisfactorily answered. You will receive a copy of the written informed consent prior to your participation in the study.

Participant’s Name (printed) ____

____ ____________________
(Participant’s Signature) (Date)

INVESTIGATOR STATEMENT – I certify that the participant has been given adequate time to read and learn about the study and all of their questions have been answered. It is my opinion that the participant understand the purpose, risks, benefits, and procedures that will be followed in this study and has voluntarily agree to participate.

____ ____________________
(Signature of Person Obtaining Informed Consent) (Date)

INFORMED CONSENT DOCUMENT

Title of Study: **Media Effects on the Neural Correlates of Decision Making**

Investigators: Robert West, PhD
Kira Bailey, MS

This is a research study. Please take your time in deciding if you would like to participate. Please feel free to ask questions at any time.

INTRODUCTION- The purpose of this study is to examine the relationship between prior media exposure and brain processes involved in decision making. You are eligible to participate in this project as part of the Department of Psychology Research participation pool. As noted on your course syllabus, participation in experiments is one of the available options for acquiring experimental credit in your psychology course.

DESCRIPTION OF PROCEDURES - You will be asked to perform four tasks that examine decision making while we record EEG (brain waves) from your scalp. In order to record the EEG you will wear a cap that contains the electrodes. In each of the electrodes we will place a small quantity of conductive gel. This gel is water based and is easy to wash out of your hair at the end of the study. The tasks, which will be presented on the computer, will be explained and any questions that you have will be answered. Before beginning the computer tasks you will complete six questionnaires measuring handedness, emotion, media usage, and decision making. The entire experiment should take less than 2 hours.

RISKS - There are no known risks associated with performing the computer tasks. Stimuli will be shapes, card, or words. There is a slight risk of developing a headache while wearing the Electro-cap. This goes away after the cap is removed. If this occurs during the study let us know and we can take steps to eliminate the discomfort. There is also a slight risk related to the transmission of pathogens (bacteria or viruses) related to wearing the Electro-cap. This risk of transmission is greatly reduced by disinfecting the caps following each use with a medical grade disinfectant.

BENEFITS- If you decide to participate in this study there will be no direct benefit to you. It is hoped that the information gained in this study will benefit society by extending our understanding of the relationship between prior video game experience, attention, and decision making.

ALTERNATIVES TO PARTICIPATION- Alternatives other than research participation for earning research/extra credit are described in your course syllabus.

COSTS AND COMPENSATION- You will not have any costs from participating in this study. You will be compensated for participating in this study by earning 3 course credits.

PARTICIPANT RIGHTS- Your participation in this study is completely voluntary and you may refuse to participate or leave the study at any time. If you decide to not participate in the study or leave the study early, it will not result in any penalty or loss of benefits to which you are otherwise entitled. You can skip any questions that you do not wish to answer.

CONFIDENTIALITY- Records identifying participants will be kept confidential to the extent permitted by applicable laws and regulations and will not be made publicly available. However, federal government regulatory agencies auditing departments of Iowa State University and the Institutional Review Board (a committee that reviews and approves human subject research studies) may inspect and/or copy your records for quality assurance and data analysis. These records may contain private information. We are required by the University IRB to keep a copy of the informed consent.

To ensure confidentiality to the extent permitted by law, the following measures will be taken: The electronic data will be stored on a password-protected computer that is in the experimenters' laboratory. Only the investigators have access to this computer. The consent form will be separated from the other data following the completion of data collection and maintained in a locked file cabinet so that there is no way to link the identity of the individual to the written or electronic data. The data collected in this research will be used for scientific purposes and may be presented at scientific meetings or published in professional journals. If the results are published, your identity will remain confidential.

QUESTIONS OR PROBLEMS- You are encouraged to ask questions at any time during this study.

- For further information about the study contact Robert West, rwest@iastate.edu.
- If you have any questions about the rights of research subjects or research-related injury, please contact the IRB Administrator, (515) 294-4566, IRB@iastate.edu, or Director, (515) 294-3115, Office for Responsible Research, Iowa State University, Ames, Iowa 50011.

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PARTICIPANT SIGNATURE

Your signature indicates that you voluntarily agree to participate in this study, that the study has been explained to you, that you have been given the time to read the document, and that your questions have been satisfactorily answered. You will receive a copy of the written informed consent prior to your participation in the study.

Participant's Name (printed) ____

_____________________________________ _____________________

(Participant's Signature) (Date)

INVESTIGATOR STATEMENT – I certify that the participant has been given adequate time to read and learn about the study and all of their questions have been answered. It is my opinion that the participant understand the purpose, risks, benefits, and procedures that will be followed in this study and has voluntarily agree to participate.

____ _________________________
(Signature of Person Obtaining Informed Consent) (Date)

INFORMED CONSENT DOCUMENT

Title of Study: **Video Games and Decision Making**

Investigators: Robert West, PhD
Kira Bailey, MS

This is a research study. Please take your time in deciding if you would like to participate. Please feel free to ask questions at any time.

INTRODUCTION- The purpose of this study is to examine the effect of playing a video game on the cognitive processes involved in decision making. You are eligible to participate in this project as part of the Department of Psychology Research participation pool. As noted on your course syllabus, participation in experiments is one of the available options for acquiring experimental credit in your psychology course.

DESCRIPTION OF PROCEDURES- If you agree to participate, you will be asked to complete 4 brief questionnaires on emotion, impulsivity, and media usage. Then you will play one of four video games for 20 minutes after which you will perform 2 computer tasks that examine decision making. The video games may contain violent content and have a rating of M for Mature. The tasks will require you to make some decisions about stimuli, which will be cards, shapes, and words. The entire study will take approximately 50 minutes to complete.

RISKS- The video game may contain violent content which you may find disturbing. If you feel uncomfortable at any point, you should inform the experimenter and they will turn the game off. There are no known risks associated with performing the computer tasks. Stimuli will be cards, shapes, or words.

BENEFITS- If you decide to participate in this study there will be no direct benefit to you. It is hoped that the information gained in this study will benefit society by extending our understanding of the relationship between prior video game experience, attention, and decision making.

ALTERNATIVES TO PARTICIPATION- Alternatives other than research participation for earning research/extra credit are described in your course syllabus.

COSTS AND COMPENSATION- You will not have any costs from participating in this study. You will be compensated for participating in this study by earning 1 course credit.

PARTICIPANT RIGHTS- Your participation in this study is completely voluntary and you may refuse to participate or leave the study at any time. If you decide to not participate in the study or leave the study early, it will not result in any penalty or loss of benefits to which you are otherwise entitled. You can skip any questions that you do not wish to answer.

CONFIDENTIALITY- Records identifying participants will be kept confidential to the extent permitted by applicable laws and regulations and will not be made publicly available. However, federal government regulatory agencies auditing departments of Iowa State University, and the Institutional Review Board (a committee that reviews and approves human subject research studies) may inspect and/or copy your records for quality assurance and data analysis. These records may contain private information. We are required by the University IRB to keep a copy of the informed consent.

To ensure confidentiality to the extent permitted by law, the following measures will be taken: The electronic data will be stored on a password-protected computer that is in the experimenters' laboratory. Only the investigators have access to this computer. The consent form will be separated from the other data following the completion of data collection and maintained in a locked file cabinet so that there is no way to link the identity of the individual to the written or electronic data. The data collected in this research will be used for scientific purposes and may be presented at scientific meetings or published in professional journals. If the results are published, your identity will remain confidential.

QUESTIONS OR PROBLEMS- You are encouraged to ask questions at any time during this study.

- For further information about the study contact Robert West, rwest@iastate.edu.
- If you have any questions about the rights of research subjects or research-related injury, please contact the IRB Administrator, (515) 294-4566, IRB@iastate.edu, or Director, (515) 294-3115, Office for Responsible Research, Iowa State University, Ames, Iowa 50011.

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PARTICIPANT SIGNATURE

Your signature indicates that you voluntarily agree to participate in this study, that the study has been explained to you, that you have been given the time to read the document, and that your questions have been satisfactorily answered. You will receive a copy of the written informed consent prior to your participation in the study.

Participant's Name (printed) ____

____ ____________________
(Participant's Signature) (Date)

INVESTIGATOR STATEMENT – I certify that the participant has been given adequate time to read and learn about the study and all of their questions have been answered. It is my opinion that the participant understand the purpose, risks, benefits, and procedures that will be followed in this study and has voluntarily agree to participate.

____ ____________________
(Signature of Person Obtaining Informed Consent) (Date)

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