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The Influence of Video Games on Adolescent Brain Activity

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THE INFLUENCE OF VIDEO GAMES ON ADOLESCENT BRAIN ACTIVITY

DISSERTATION

A dissertation submitted in partial fulfillment of the
requirements for the degree of Doctor of Philosophy in the
College of Agriculture, Food and Environment
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By
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Lexington, KY

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ABSTRACT OF DISSERTATION

THE INFLUENCE OF VIDEO GAMES ON
ADOLESCENT BRAIN ACTIVITY

The current study examined electrical brain activations in adolescent participants playing three different video games. Forty-five school aged children (*M*=14.3 years, *SD*=1.5) were randomly assigned to play either a violent game, non-violent game, or a non-violent game specifically designed to "train" the brain. Electroencephalography (EEG) was recorded during video game play. Results revealed an asymmetric right hemisphere activation in the alpha band for participants in violent game group, while those in the non-violent groups exhibited left hemispheric activation. Greater right activation in emotion literature denotes signs of withdrawal or avoidance from undesired stimulus. Implications of this finding as well as other findings related to electrical brain activation during video game play is discussed further in the manuscript.

KEYWORDS*:* Video Games, Brain Training, Media Effects, EEG, Adolescents

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April 16, 2014
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THE INFLUENCE OF VIDEO GAMES ON
ADOLESCENT BRAIN ACTIVITY

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DEDICATION

To my mom and dad.

Thank you for teaching me that the only limits in life are the ones you set yourself. Most of all, thank you for teaching me the value hard work. Everything I am is because of you.

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Chapter One

Introduction

In a 2012 survey by the Entertainment Software Association, a well-known association dedicated to various public and private interests of video games and computers, found that almost half of the 2,000 represented households owned a dedicated game console. Game consoles were defined as a specialized computer used to play video games on a TV or display monitor. Total consumer spending on video game accessories, content, and hardware accounted for a $24.75 billion dollars alone in 2011 (ESA, 2012). The significance of digital gaming in today's society is best described by Michael D. Gallagher, president and CEO of the Entertainment Software Association, "Computer and video games have reached a critical mass. Today, nearly every device with a screen plays games, providing interactive entertainment experiences for a wide and diverse population (ESA, 2012, pp.1)."

Given the increasing popularity and prevalence of video games, social scientists have put forth great effort into understanding the potential effects of this type of media entertainment (Sestir & Bartholow, 2010). Behavioral research have found video game play to be associated with positive outcomes such as increased response accuracy and attentional skills (Dye, Green, & Bavelier, 2009) as well as negative outcomes concerning obesity (He, Piché, Beynon, & Harris, 2010), poorer school performance (Gentile, Lynch, Linder, & Walsh, 2004), and aggressive behavior (Anderson, 2004) to name a few. With game players 18 or younger representing 32% of all those who play (ESA, 2012) video games, effects are of particular concern for the adolescent population because they may be easily influenced by game content during a particular time in their lives that marks rapid physical and cognitive growth, thereby influencing developmental changes (Anderson, Gentile, & Buckley, 2007). Adolescence also marks a period of increased rates of anti-social and risky behavior as well as increased rates of mental illness (Green & Bavelier, 2006), making them a vulnerable population.

The video game medium has been cited as a complex and challenging area of research due to the many different aspects involved in game playing such as player perspective (i.e., first person vs. third person) or different types of game content (i.e., violent, non-violent) (Green & Bavelier, 2006). Violent video game content has been the primary focus of investigators, due to the concern that gratuitous violence and interactive nature of gaming may lead to increased aggression outside of the game environment. However, researchers cannot agree as to whether violent video game content influences behavior, thought, and affect, even after 30+ years of investigation (Sherry, 2001). Other investigations, though not quite as prolific as behavioral studies, are now using physiological measures, such as heart rate measures (Ballard & Wiest, 1996), skin conductance (Ravaja, Turpeinen, Saari, Puttonen, & Keltikangas-Järvinen, 2008), or electroencephalography (Salminen & Ravaja, 2007) to better understand the effects of video games.

The aim of the present study is to better understand the influence of video game content on electrical brain processes of adolescents, an area currently understudied. The present study proposes to examine brain waves, using quantitative electroencephalography (EEG), in adolescents playing violent and non-violent games to better understand the physiological effects of emotional and cognitive reactivity to game content. By investigating adolescent brain activity, more information may be gathered on how video games possibly influence on the developmental process. Quantitative EEG describes a method of quantifying brain activity using algorithms to understand the spectral content of the brain's electrical signals (Kaiser, 2006). For those unfamiliar to the EEG methodology or those just needing a refresher, later sections of this manuscript will cover fundamental information needed for comprehension of the current study.

Outline of Manuscript

Since there are many different topics within this manuscript, a brief explanation of each section of the paper's organizational flow is outlined under four major foci: *behavioral media research, theoretical perspectives*, a*dolescent development* and *EEG-related information*. The first section, *behavioral media research,* covers the breadth of topics related to video game studies and studies related to its media counterpart, television. An explanation of video game ratings systems is provided for context, followed by a review of studies aimed at different types of video games based on content (i.e., violent and non-violent). Since video game research has often been related to research involving television viewing, a short review of this media research is given. More recent video game research has identified adolescents not only playing individually, but with their families (Coyne, Bushman, & Nathanson, 2012). In light of this finding, a small section is devoted to video games in family life. With games producing both positive and negative outcomes, this section may be useful to therapists and other professionals working with parents of adolescents to make an educated decision about the involvement of games in their family life.

The second area of focus concentrates on different *theoretical frameworks* used to understand video game outcomes, both behaviorally and physiologically. The third area of focus, *adolescent development*, discusses the adolescent life stage. This information is necessary to create a firm argument on why investigating electrical brain activity may add to existing video game literature and provide greater insight to how video games may influence brain development.

The last area of emphasis, *EEG-related information,* covers fundamental information needed to understand EEG and how it is used in research. The few research studies that have been conducted using EEG methodology to examine psychological and physiological brain correlates of video games is also discussed in this section.

Chapter Two

Literature Review

Video Games in the Media

The Entertainment Software Review Board (ESRB) created a rating system for video games and software as a way to classify age-appropriate content. Games are rated based on content such as sex, violence, and language. Violent game research in existing literature usually involve games with violence defined as aggressive conflict, graphic and realistic-looking depictions of physical conflict, extreme and/or realistic blood, gore, weapons and depictions of human injury and death (Gentile, Humphrey, & Walsh, 2005). Instances of mild to intense violence are present in games rated E for everyone to AO, adults only. Games used in experimental studies can be categorized as "fighting games" in which characters battle one another in combat or "shooter games," requiring playing to complete missions using their armed avatar. Non-violent video games, often used as a comparison condition, typically do not involve any instance of violence or physical conflict. These games contain activities such as solving puzzles or completing innocuous missions such as finding objects hidden throughout the game (Gentile, et al., 2005).

Since the technological advancement of video games, there has been some concern over the influence of violent content on children's behavior. Prominent video game researcher C. A. Anderson (2004) noted that serious concern over the effects of violent video games increased with national attention towards a series of school shootings at West Paducah, KY in 1997, Jonesboro, AK in 1998, Springfield, OR in 1998, and Littleton, CO in 1999. Perpetrator(s) involved in all four shootings were avid gamers, a term that refers to those who play computer or video games. Even currently, his supposition holds true. Since those school shootings, popular media has blamed numerous other violent crimes in recent years on violent game playing. One such example is the Sandy Hook Elementary tragedy that took place December 14, 2012. Law enforcement revealed that the twenty year-old perpetrator, responsible for the death of 20 students and 6 adults, was discovered to have spent hours alone in his blacked out basement playing violent shooter games (Jaslow, 2013). Each time tragedies such as Sandy Hook take place, the flames in the long debated question of whether violent games influences aggressive and violent behavior in the player are fueled.

Violent Video Game Play among Adolescents

Human aggression is often used as an outcome defining the effects of violent media. While the definition of aggression has been interpreted in different ways, social psychologists and human aggression researchers define this construct as "(a) a behavior that is intended to harm another individual, (b) the behavior is expected by the perpetrator to have some chance of actually harming that individual, and (c) the perpetrator believes that the target individual is motivated to avoid harm (Anderson, et al., 2007, pp. 13)." Video game research has used this definition to examine different types of aggressive behaviors or thoughts such as physical (e.g., hitting, shooting) or verbal (e.g., harming someone through written or spoken words).

Evidence for a direct causal relationship between aggression and gaming has been widely reported in the literature (e.g., Barlett, Harris, & Baldassaro, 2007; Farrar, Krcmar, & Nowak, 2006). For example, researchers Barlett, Harris, and Baldassaro (2007) had ninety-nine participants (M = 19.2 years of age) play a first person shooter game where the objective was to infiltrate an island taken over by enemy forces for 15 minutes. Heart rate was taken at baseline, during middle of the game session, and immediately preceding the gaming session. State aggression and hostility measures were also taken before and after game play. Results indicated that heart rate, state aggression, and state hostility significantly increased from baseline over a short period of time. Results provided support for short-term effects of increased aggression due to violent video game exposure.

Long-term effects of video games have also been documented (Anderson et al., 2008; Wallenius & Punamäki, 2008; Gentile et al., 2011). Longitudinal study by Wallenius and Punamaki (2008) surveyed students from Finnish elementary and middle schools. Participants included 222 fourth graders (*M*=10.27 years of age) and 256 seventh graders (*M*=13.28 years of age). Methodology in this study was similar to the approach used by Gentile, et al. (2004) discussed previously. Participants were asked how often they played violent video games such as killing, fighting, attacking, or kicking using a 4-point Likert scale ranging from "0=not at all" to "3=very often." Aggression was measured by 10 items from the Direct & Indirect Aggression Scale which describes physical aggression towards others (e.g., "I might hit a person when I'm irritated" or "I kick and hit"). Two years later, 316 of those participants (132 participants from the sixth graders and 184 participants from the ninth graders) returned follow-up questionnaires. Wallenius and Punamaki (2008) found a short and long term effect associated with violent video game play and aggressive behavior.

Several meta-analytic studies have also been conducted using relevant literature on video games (e.g., Anderson & Bushman, 2001; Anderson, 2004). Results showed strong evidence that violent video game exposure is associated to increased aggressive affect, behavior, cognition, and physiological measures. Effect sizes of studies used in the meta-analysis were found to be significantly different from zero. Aggressive behavior was consistently associated with violent video game play across studies and age groups (i.e., young and older). In a meta-analysis by Anderson (2004), literature specifically testing video game effects on child samples were assessed. Findings were consistent with previously conducted meta-analyses (Anderson & Bushman, 2001), which showed violent video game exposure increased aggressive affect, behavior, and cognition. Due to insufficient number of studies available, literature on video game effects on children's physiological arousal could not be assessed.

Alternative Findings

Despite the breadth of findings showing an association between violent game playing and aggression, the results on violent game effects are far from conclusive. Not all researchers have found support for the relationship between violent video game playing and aggression in youth (e.g., Winkel, Novak, & Hopson, 1987; Graybill, Strawniak, Hunter, & O'Leary, 1987; Scott, 1995; Unsworth, Devilly, & Ward, 2007).

From an opposing viewpoint, some researchers believe the effect of video game violence on aggression is minimal to non-existent (Ferguson et al., 2008; Ferguson, 2008). Support for this claim is strengthened by findings from longitudinal (Williams & Skoric, 2005) and other published meta-analysis studies concerning the effects of violent video game exposure on aggression conversely show no relationship between violent video game play and aggression (Ferguson, 2007; Savage & Yancey, 2008; Ferguson & Kilburn, 2010). The authors of these studies argue that the effects of violent video games are small, making it difficult to establish a causal relationship between game violence and aggression (Sherry, 2007). Meta-analytic reviews are cited as useful in providing objective summaries of a body of literature (Anderson et al., 2007), investigating wide ranges of variables in studies, and are not prone to problems with the mixed results of significance testing that individual studies face (Sherry, 2007). So why are there discrepant findings concerning the effects of violent video games?

Ferguson and Kilburn (2010) argue that publication bias, in which journals selectively published studies with significant findings only, may be one reason meta-analyses resulted in detecting linkages between violent video game play and aggression. Report types may range from journal articles, to technical reports or conference presentations. Therefore, running meta-analysis only with published reports would yield larger effect sizes than if all report types were included (Lipsey & Wilson, 2000).

Another reason why there are discrepant findings on the effects violent video games may be because some researchers include other existing variables such as previous exposure to violence, personality, or genetics as possible predictive indicators of aggression, while other researchers do not account for such variables in their studies (Ferguson, 2008). For example, Ferguson, et al. (2008) investigated the influence of violent video games on violent criminal behavior. College undergraduates took part in the study (N=428) by completing various measures of past video game habits and exposure to violent video games, trait aggression, exposure to family violence (e.g., experience with physical and sexual abuse, domestic violence, drug abuse, spanking, etc.), and self-reported violent criminal behavior. Ferguson et al. (2008) posited that if a unique link between violent game playing and violent behavior existed, violent video game playing habits would hold a significant amount of predictive variance, after controlling for exposure to family violence in a correlation design model. However, results indicated that this was not the case. After controlling for family violence, violent video game playing habits was not a significant indicator to violent criminal behavior, but that exposure to physical and verbal abuse seemed to be more pertinent predictors.

In response to recent meta-analyses by Ferguson and colleagues (2007, 2008), Anderson et al. (2010) conducted another meta-analysis further investigating specific aspects of violent game effects, including a host of new relevant studies since 2004. Other important aspects of video games such as player perspective (first person vs. third person), human vs. non-human targets, and player age (young vs. older) were also addressed. Results still showed violent video games were positively associated with aggressive behavior, cognition and affect, with a relation to desensitization to graphic content and lowered prosocial behavior. Factors in gaming experience (i.e., player perspective, player role, time game, and human/nonhuman target) significantly influenced aggression (Anderson et al., 2010). While a large body of research show results supporting the relationship between violent video games and increased aggression, discrepant findings makes it difficult to reach a definitive stance on the topic.

Related Media Research on Violence

Video game research has often been paralleled to literature on television and media violence. Discrepant findings are also found within the body of literature concerning violent media effects. One defining study in early television and media research was conducted by Hartnagel, Teevan, McInyre (1975), who examined questionnaire data from adolescents in an effort to understand the relationship between exposure to television violence and violent behavior. Junior and high school students were asked to list four of their favorite television shows because favorite television programming was believed to be viewed more closely and frequently than other shows. While total exposure to violent programming was not collected, overall television viewing data was collected to control for possible effects on behavior.

Violence ratings were assigned to each program listed by participants and a mean violence rating was calculated for all shows (Hartnagel, Teevan, & McIntyre, 1975). Violence ratings were taken from a survey of television critics and were highly correlated with general public opinion on ratings. Violence was defined as the frequency of fighting, shooting, yelling, or killing present in the television show. Violent behavior was measured by the following: got in a serious fight at school, hurt someone badly, and took part in a fight with friends against another group of people. Frequency of these behaviors were measured as never, once, and two or more times. Hartnagel, Teevan, and McIntyre (1975) found little support that exposure to television violence was associated violent behavior. Instead, other predictor variables such as sex, age, race, and school performance provided stronger linkages to predicted violent behavior (Hartnagel, et al., 1975).

Despite findings by Hartnagel, Teevan, and McIntyre (1975), negative behavioral, cognitive, and affective outcomes of violent television effects are well documented (Johnson, Cohen, Smailes, Kasen, & Brook, 2002). In a 17-year longitudinal study, Johnson, and colleagues (2002) interviewed 707 families with children between the ages of 1-10. Television viewing and aggressive behaviors were assessed at 4 different time periods: 1975, 1983, 1985-86, and 1991-93. Follow-up questionnaires were completed by children who reached consenting age at the end of the study. Controlling for previous aggressive behavior prior to the study, childhood neglect, family income, neighborhood violence, parental education, and psychiatric disorders, the relationship between the amounts of time spent viewing television violence and subsequent aggressive acts committed after the start of the study was significant. Results indicated violent television viewing during childhood was associated with increased aggressive acts in adulthood.

In another related study, Polman, et al. (2008) investigated the differences between watching violent video games compared to actively playing a violent video game. Children aged 10-13 (N=57) were placed into three different groups: play violent game, watched same violent game, or the condition group which played a non-violent game. While similar and often compared to media research, video games are distinctly different in that the player has control over a character's behavior and directs the character to engage in violent acts. With this line of reasoning, it was hypothesized that children playing the violent video game would display more aggression than children watching the violent game play and children playing the non-violent game. Polman and colleagues tested their assumption by recording aggressive behavior throughout the school day (i.e., hostile kicking, hitting, pushing someone) as a measure of aggression. This is a commonly used approach to measure aggression and a similar methodological approach used in the media study previously discussed by Johnson, et al. (2002). Results showed boys playing a violent video game increased aggression more than boys watching the same video game, but there were no significant results for girls. The researchers suggested the small sample size could be one reason why an effect was not detected for females (Polman, et al., 2008).

Video game studies mirror a lot of similar problems with discrepant findings as investigations into media effects of television. Although video games are a recent technology flourishing within the last 20 years, media research focusing on television and films have been scrutinized for the past 60 years (Anderson et al., 2010). By understanding and isolating issues existing research on related media such as television and films, researchers may better address possible problems with video game research design to finally reach a consensus about its influence on aggressive behavior.

Non-Violent Video Game Play among Adolescents

Amidst the debate between possible media effects and aggression, other researchers remind us that like television, video games should not be viewed as either good or bad (Gee, 2007). Just as there are negative findings, there are also positive outcomes to game play. Not all video games have deleterious effects. Teachers have found it imperative to keep up with popular culture in order to motivate students in the classroom. Literacy rates in children are reported to increase with the use of educational games such as reading role-playing video games in course curriculums (Adams, 2009). Non-violent video games have been found to result in positive outcomes ranging from improvements in visual processes such as visualization and spatial ability to enhanced cognitive functioning through more efficient information processing and information integration (Barlett, Vowels, Shanteau, Crow, & Miller, 2009).

For example, Barlett, et al. (2009) conducted a study exploring three different conditions: violent video game, non-violent video game, and no game play. Participants who did not play a video game were given a task of searching the internet for air controller information. Cognitive performance was measured by memory, addition, auditory perception, and selective attention tasks taken prior to the game or internet search and afterwards. Non-violent gamers played two games that were clearly void of any violent content. The first was tile game in which they were asked to find and match one tile to a duplicate tile. The second was a numbers game in which participants had to identify numbers within a certain range such as 3 and 17. The violent video game required participants to build a military base and defend the base from attacks. The results of this study by Bartlett and colleagues (2009) revealed that those who did not play a video game had no change in their cognitive performance. However, those in the video game conditions, regardless of type, had an increase in cognitive performance. Both types of video games had similar increases, suggesting that content had no effect on overall cognitive outcomes and that the participants who played video games were able to transfer skills acquired during the gaming session. The implications of this research (Barlett, et al., 2009) suggest that there is value in video game play and that non-violent games can be just as effective in increasing cognitive performance as violent games, without the potential deleterious aggressive influence on adolescent development.

The effects of computer games on cognitive performance is becoming of particular interest as a possible tool to reverse age-related declines. Research have identified widespread age-related differences in cognition associated with a wide range of brain functioning such as processing speed (Salthouse, 2000), working and episodic memory (Salthouse, Atkinson, & Berish, 2003), and dual-task processing (Crossley & Hiscock, 1992). A surge of *brain training* games designed to increase cognitive functions have entered the video game market. However, many of these game designs have not been stringently tested by the scientific community as effective (Baniqued et al., 2013), especially with select populations. Brain training is still a relatively new area of research. It is still unclear whether cognitive changes associated with brain training games are population specific. While modest training effects have been found for older adults (Papp, Walsh, & Snyder, 2009)and pre-school aged children (Smith et al., 2009), evidence of brain training effectiveness has yet to be found in wider populations.

Owen et al. (2010) tested brain training effectiveness among participants between the wide age ranges of 18 to 60 years. People were recruited to engage in online training tasks through the course of six weeks. Participants (N=11,430) played tasks that required reasoning, verbal short term memory, verbal spatial memory, and paired associates learning for 10 minutes at least 3 times a week. At the end of the study, Owen and colleagues (2010) found that although there were overall improvement in task performance, there were no evidence of transfer effects to other untrained tasks, even tasks that required similar cognitive processes. Future research may be useful to identify cognitive processes used in specific tasks to further develop brain training tools that would prove effective to a wider audience.

In addition to increased cognitive performance, video games have also been linked to prosocial behavior (Anderson & Bushman, 2001; Chambers & Ascione, 1987; Greitemeyer, Osswald, & Brauer, 2010). Prosocial behavior is operationalized as the act of helping others. Studies have found that video games with prosocial content increased empathy and decreased schaudenfraud, defined as feeling joy as a result of other's misfortune (Greitemeyer et al., 2010). Some evidence have also been found that non-violent content in video games may also result in more prosocial behavior.

Sestir and Bartholow (2010) studied the effects of not playing a game versus playing a violent or non-violent video game on aggression and prosocial outcomes. Participants completed several measures of aggression and a story completion task. The story completion task involved listening to three different incomplete stories and then providing 15 items describing what could happen next. Responses were rated as aggressive, prosocial, or neutral by two judges. Aggressive responses were considered to be any content that could harm someone. Prosocial responses were behaviors, thoughts, and emotions that benefitted others well-being such as helping someone. Agreement on content ratings were high and had strong inter-rater reliability (ICC=.88). Researchers found that participants who played the non-violent game gave significantly more prosocial responses on the story completion task than those who played violent video games and compared to those who did not play any type of video game. Participants in the non-violent game condition also provided fewer aggressive responses than those who did not play a video game. Sestir and Bartholow (2010) concluded that non-violent games increased the accessibility of prosocial cognitions, even though the non-violent video game contained no prosocial content by enhancing executive functions such as logic and reasoning.

Video Games and Family Life

Playing video games may once have been considered a singular past-time, but in today's social context, it is considered a source of family entertainment (ESA, 2012). When surveyed, 40% of parents reported playing games with their children on a weekly basis because it is fun family time and their children request it. Parents believed gaming was a positive part of their child's life because it provides mental stimulation, encourages family time, and makes it easier to connect with their friends (ESA, 2012). These beliefs are not unfounded. There are a wide breadth of empirical evidence supporting the positive outcomes of video games, such as the benefits of parent's co-playing games with their child(ren) (Coyne, Padilla-Walker, & Day, 2011).

Family Togetherness. Family togetherness takes place through playing video games (Mitchell, 1985). In a survey of 5th and 6th graders, children listed "spending time with family" as one of three top reasons for watching television and playing video (He et al., 2010). Media use has been used as a means of increasing family connectivity. Studies show that families using media through cell phone usage, text messaging or video conferencing report increased feelings of connectedness (Wei & Lo, 2006; Judge, Neustaedter, Harrison, & Blose, 2011; Pettigrew, 2009). Families who watch television together also report positive outcomes. Children co-viewing television together with their parents report greater understanding of content (Collins, Sobol, & Westby, 1981) and increased critical viewing skills (Corder-Bolz, 1982). Although new studies these results suggest media is beneficial, it cannot be assumed that video games have similarly positive effects on family togetherness.

A nationally representative survey in 2012 found that parents of children aged 12 to 17 were more likely to co-play video games as a family past time if they believed video games had positive effects (Shin & Huh, 2011). A seminal study by Coyne, Padilla-Walker, and Day (2011) investigated the intended effects of co-playing video games on family relations. Researchers wanted to know if co-playing increased family connectedness and examine outcomes related to game play. Eighty-seven mix structured families participated (106 single parent, 190 two parent) in the study by answering questionnaires about the mother, father, and child's game playing habits. Co-playing variable was obtained by asking how often the child played with a parent (Likert scale 1 = never, 6=more than once a day). Internalizing behaviors, delinquency, aggression, prosocial behavior, and parent-child connection was also measured. Interestingly, co-playing did not differ as a result of family structure or ethnicity. Results suggested that there were positive outcomes concerning family connectedness and behavior associated with parent's co-playing video games with their child. Girls, in general, had the most favorable outcome as a result of co-playing, while boys had little effect. Girls showed lower internalizing (e.g., depression/anxiety), lower aggressive behavior, more prosocial behavior towards family members, and co-playing was marginally associated with higher levels of parent-child connectedness, especially during age-appropriate game play. It was suggested that positive results from their study may be from parents sending the message that they care about their daughter's past-time or that co-playing is seen as spending quality time with one another. For this study sample, boys tended to play more often than girls, but spent about the same amount of time co-playing with a parent as girls did. The researchers speculated that the lack of effect present for boys may have been cancelled out because of higher levels of game use on average compared to girls.

A more recent study by Padilla-Walker, Coyne, and Fraser (2012) show that higher levels of family connection can be achieved through the use of media, including playing video games with one another. Padilla-Walker and colleagues sought to examine and compare how multiple forms of family media use through cell phone usage, co-viewing television and movies, co- and playing video games, emailing or social media interaction are associated with family connectedness as reported by parents and adolescents. Family connectedness in this study was defined as having a "close, warm, loving, positive relationship between parents and children (pp. 429)." Four hundred and fifty-three families (31% single parent, mother-headed families) completed questionnaires on family media use such as "How often do you text or call your parent/child or how often do you play video games with your parent/child? Parent-child connectedness was measured using the warmth/support subscale of the Parenting Styles and Dimensions Questionnaire-Short Version (Robinson, Mandleco, Olsen, & Hart, 2001). Results indicated that email and social networking between family members were not associated with strong levels of connectedness. However, cell-phone use and co-viewing movies and television, the most common forms of media used by families, were significantly associated with higher levels of family connectedness. Cell-phone use were proposed to reflect a way for parents and adolescents to communicate with one another through a different context. Co-viewing, the most passive of media use, strengthened family closeness by having a shared interest in programming or just spending time together. Interestingly, Padilla-Walker and colleagues (2012) reported that only about 30% of adolescents played video games with their parents, but that co-playing was significantly related to higher levels of family connectedness for both girls and boys. One such explanation for this finding could be the interactive nature of co-playing or the shared interest of game playing. Findings from this study show positive outcomes in family togetherness can be fostered through the use of shared media such as co-playing video games (Padilla-Walker, et al., 2012).

Parental Mediation. Although co-playing video games between parent and adolescents show positive results, it is not a common shared activity in families (Padilla-

Walker, et al., 2012). However, individual video game play still remains a popular pastime among adolescents. Longitudinal national surveys reveal video game playing among youth has increased by at least 45 minutes since 1999 (Rideout, Foehr, & Roberts, 2010). Children are now playing games approximately 73 minutes a day (Rideout, et al., 2010). Parental mediation of technology such as video games is often cited as important in reducing negative effects of media exposure (Gentile, Nathanson, Rasmussen, Reimer, & Walsh, 2012). While most research concerning parental monitoring of media has been conducted with television viewing or internet usage, more recent investigations suggest parents use similar methods to monitor aspects of their child(ren)'s video game playing (Nikken & Jansz, 2004). Three forms of parental monitoring of media have been identified as *active mediation*, *restrictive mediation*, and *co-viewing* (Bybee, Robinson, & Turow, 1982; Chakroff & Nathanson, 2008; Nathanson, 2001).

Active mediation involves communication and discussion between the parent and child about media content during usage (Nathanson, 2001). Active mediation works to influence the child's perspective, teaching them to be critical consumers of media (Singer & Singer, 1986; Austin, 1993). *Restrictive mediation* refers to setting limitations on either the child's viewing/playing content and/or limits on the amount of time children may engage in media content (Chakroff & Nathanson, 2008). Overall, children of parents utilizing this mediation approach generally spend less time with media (Atkin, Greenberg, & Baldwin, 1991; Rideout et al., 2010). The last type of mediation technique used by parents is *co-viewing* or *co-playing*, where parents and children engage in media usage together (Nathanson, 2001; Nikken & Jansz, 2006). Research investigating co-viewing suggest this mediation style is particularly useful if parent's use opportunities to discuss negative content (Nathanson, 2001). Both co-viewing television programs and co-playing video games have been associated with increased family connectedness (Padilla-Walker, et al., 2012).

Theoretical Framework and Models

Several theoretical frameworks may explain the effects of video game on adolescents. Early theories in 1970's such as theory of cognitive development (Piaget, 1976), social learning theory (Bandura, 1977), general arousal theory (Zillmann, 1971)) focused on specific social-cognitive processes to understand the impact of media violence on developmental changes (Anderson et al., 2007). While early theories were advantageous in explaining the specific processes leading to video game effects, there was a shift in the early 1990's that led to the integration of several theories into more general models (Anderson et al., 2007). A more current and widely used framework for understanding media outcomes, the General Aggression Model (Anderson & Bushman, 2002) incorporated early social-cognitive theories to create a comprehensive model for understanding media influences on behavior. The theory of cognitive development (Piaget, 1976), social learning theory (Bandura, 1977), general arousal theory (Zillman, 1971) will be discussed briefly in subsequent paragraphs of this section to provide context to which the General Aggression Model (Anderson & Bushman, 2002) can be understood.

Theory of Cognitive Development. Piaget (1976) proposed that by the age of 11, humans reach a formal operational level of cognitive development which allows for logical thinking about concrete and abstract concepts. Piaget's theory of cognitive development (1976) is based on a constructivist viewpoint in which humans actively shape their knowledge about the world around them. *Schemas*, a type of mental framework or representation, help people make sense of the information processed. New experiences are constantly being assimilated or incorporated into our knowledge base (Craig & Dunn, 2007). Some researchers believe that aggression and violence are socialized as a part of cultural norms and manifested through behavior not based on conscious processes, but as unconscious automatic *schemas* (Gilgun & Abrams, 2005).

Studies do show support that cultural norms and factors such as context moderate the effect of media studies (Anderson, et al., 2010). Japanese studies on violent media effect size is smaller than Western studies possibly because violence is portrayed with focus on empathy for the victims and a clear message that such violent acts lead to consequences (Kodaira, 1998). Video game effect sizes have also produced similar cultural differences. Some evidence indicates video game effect sizes are larger in Western compared to Eastern cultures, although these findings were found in only non-experimental studies (Anderson, et al., 2010).

Social Learning Theory. Social learning theory posited than one's behavior is a learned outcome mediated between psychological processes and their direct experiences (Bandura, 1977). Social learning theory suggests that development is continuous and occurs as people respond to their environments throughout all ages (Craig & Dunn, 2007). The theory suggests that people are passive observers and in turn, form opinions about themselves based on those observations. Regarding the adolescent period, children begin to make sense of the world around them by observing models or events. From the behaviorist viewpoint, this type of learning effects both cognitive and social processes.

When an observed model is rewarded or repeated (rehearsal), the child is more likely to identify with the model (Fleming & Rickwood, 2001).

When playing video games, violent acts committed are often rewarded through increased points accumulated or other game-oriented benefits. Aggressive behavior, behavior that is intended to hurt another, is then modeled through repeated exposure through continuous video game playing and the child is then more likely to engage in the behavior (Fleming & Rickwood, 2001). Research suggests adolescents identifying with violent video game characters engage in aggressive behavior more frequently than children who are not exposed to violent games (Konijin, Bijvank, & Bushman, 2007). Numerous studies have investigated the cognitive and behavioral effects of playing violent video games among adolescents and report its association with aggressive behavior (e.g., Gentile, et al., 2004; Barlett, et al., 2007).

General Arousal Theory. Schachter's (1964) General Arousal Theory proposed that emotional states are a function of the individual's physiological arousal (Schacter, 1977). Thus, manipulation of the intensity of physiological arousal would reduce or increase emotional states. Zillmann (1971) added to this framework by testing the *misattribution of excitation transfer,* emotional states provoked by an unrelated source. Zillman (1971) and other researchers testing this hypothesis (Cantor, Zillmann, & Bryant, 1975) found that when individuals misattributed arousal caused by outside sources, the emotional state was intensified. Several studies suggest that violent video game play influences physiological changes, increasing heart rate (Barlett, Harris, & Bruey, 2008) and skin conductance (Arriaga, Esteves, Carneiro, & Monteiro, 2006) coinciding with increased hostility. As suggested by the general arousal theory, increased arousal caused by violent game play may heighten emotion from an unrelated situation such as someone accidentally bumping into them, causing the individual to react more intensely or aggressively than they would normally have reacted.

General Aggression Model. By adopting key ideas from the aforementioned theories and other well established concepts, the General Aggression Model (GAM) provides an interpretation for social, cognitive, and biological influences that may affect aggressive outcomes (Anderson & Bushman, 2002). Aggressive behavior, cognition, and affect in this model is based on the assumption that, "The enactment of aggression is largely based on the learning, activation, and application of aggression-related knowledge structures stored in memory (e.g., scripts, schemas) (Anderson & Bushman, 2001, pp. 355)."

Knowledge structures are concepts that are strongly linked or connected (Anderson et al., 2007). Anderson and Bushman (2001) identify five knowledge structures that may be changed through repeated exposure to violent media: aggressive beliefs and attitudes, aggressive perceptual schemata, aggressive expectation schemata, aggressive behavior scripts, and aggressive desensitization. As knowledge structures are reinforced through continual exposure to violent media content, they become more difficult to change and automatized.

In its most general explanation, GAM proposes that distal factors (i.e., biological and environmental) influences proximate causes, factors close in proximity, which will lead to either increase or decrease inhibitions towards aggression (Anderson et al., 2007). Distal factors and proximate causes as it relates to video game outcomes is presently discussed.

Distal factors. Distal factors, defined as original distant causal factors (Abramson, Metalsky, & Alloy, 1989), play an important role in the General Aggression Model. An individual's biology can be considered a distal factor. From a biological viewpoint of development, the brain continues to develop through adolescent life stage and is greatly affected by hormones produced by puberty (Craig & Dunn, 2007). Specific areas of the brain are also targeted by hormones, such as the amygdala, responsible for emotional regulation. When emotions are triggered by hormones, emotions may become volatile. Activation of the amygdala is also related to risk-taking behavior (Steinberg, 2007). The repeated influence of violent video game play may not be a positive influence to adolescents who must already deal with heightened emotions and risk taking behavior (Craig & Dunn, 2007).

Kirsch (2003) provided a concise review of biological and physical causes of adolescent aggression and how video games may serve as a function of developmental changes to that specific type of behavior (Kirsh, 2003). Research have found adolescent aggressive responses to hypothetical conflict situations tend to follow a curvilinear pattern, with increased aggressive responding occurring throughout ages 11 to 14 years of age (early adolescence) and decreasing between 14 to 17 years of age (middle adolescence) (Lindeman, Harakka, & Keltikangas-Järvinen, 1997). Other studies have found a similar pattern for rate of physical aggression (Loeber & Stouthamer-Loeber, 1998) and parent-teen/sibling-teen conflict (Steinberg & Morris, 2001).

Interestingly, a functional magnetic imaging (fMRI) research study conducted at the McLean Hospital found evidence indicating that early and late adolescent brains may function differently in activation of brain regions in response to certain stimuli (Killgore

& Yurgelun-Todd, 2007). Sixteen adults and 18 children between the ages of 10 and 18 viewed emotion laden pictures during brain scans and were asked to identify the emotion shown in the picture. Adults correctly identified the emotions shown, but teens had more difficulty identifying the expression shown in the pictures. Brain scans revealed that teens and adults use different parts of the brain to process the information shown. Killgore and Yurgelun-Todd (2007) found that teens often used the amygdala, a structure of the brain linked to emotion and aggression (Coccaro, McCloskey, Fitzgerald, & Phan, 2007), to process information, while the adults relied on their frontal cortex. The frontal cortex brain region is largely associated with higher cognitive functioning such as attention, information processing, and planning of appropriate responses to incoming stimuli (West, 1996) Furthermore, as teens got older, activity moved towards the frontal cortex and away from the amygdala. This may suggest maturation in emotional processing.

Biological influences such as personality may also be responsible in how an individual expresses certain types of behaviors (Anderson et al., 2007). For example, Anderson and Dill (2000) polled college students on their 5 favorite video games. Students also completed aggressive personality measures. The results of this study indicated that exposure to violent video games was associated with aggressive behavior and real life delinquency, with the association stronger for those with more aggressive personalities (Anderson & Dill, 2000).

Proximal causes. As mentioned earlier, distal factors (i.e., biology) facilitate proximal causes which can be individual-oriented such as aggressive scripts or situation-oriented such as provocation, which in turn interacts with a person’s internal state—

represented through affect, cognition and arousal (Anderson et al., 2007). The individual's internal state then engages appraisal and decision making processes which thereby leads to action. The theory suggests that repeated exposure to violent video games (distal factor) can influence someone's mood or change their knowledge structure to a more aggressive outlook, also affecting their internal states. When a situation arises that requires assessment, these factors will influence the decision making process and may result in aggressive behavior. The strength of the General Aggression Model is that it is developmental in nature, allowing researchers to predict change in time by age correlated abilities (Anderson et al., 2007). Another strength of the model is that it is testable.

To uncover the effects of violent video game use on adolescent hostility and aggressive behaviors, Gentile, Lynch, Linder, and Walsh (2004) anonymously surveyed 607 eighth and ninth graders (M =14 years old) in Midwestern schools about their attitudes, knowledge of video games, and parental limitations on the type of game and amount of time spent playing. Violence ratings were self-reported using a 7-point Likert scale ranging from "1=Little" to "7=Extremely Violent." Students were also asked questions about how often they argued with teachers in the past year using a 4-point Likert scale response ranging from "Almost Daily" to "Less than Monthly." Students answered yes or no to indicate how often they got into physical fights in the past year. Aggressive behaviors were defined as arguing with teachers and engaging in physical altercations. The survey also included a measure of trait hostility (Cook & Medley Hostility Scale).

According to the GAM, Gentile, Lynch, Linder, and Walsh (2004) hypothesized that video game violence would be associated with trait hostility (distal factor) and also associated with aggressive behaviors (proximate cause). Results supported both hypotheses predicted by the GAM. Students who had played more video games were more likely to have been involved in physical altercations and arguments with their teacher, both actions were used as a measure of aggressive behavior. Participant trait hostility scores were significantly correlated with the amount of violence preferred in a video game and the amount of exposure the adolescent had with violent games. Gentile et al. (2004) concluded exposure to violent video game play is associated with increased aggressive behavior and hostility in adolescent children.

In another study showing support for the GAM, Gentile and Stone (2005) investigated studies lacking a nonviolent video game control group and studies that did not adjusting for confounding affects such as frustration, difficulty, or excitement. Researchers analyzed video game research that had a nonviolent video game control, controlled for confounding effects, and utilized the Generalized Aggression Model, a psychometrical scale deemed valid and reliable measure of aggression to predict increased aggressive affect, increased physiological arousal, increased aggressive cognitions, and increased aggressive behaviors. Results found significant evidence that violent video game play is related to aggressive affect, physiological arousal, aggressive cognitions and aggressive behaviors (Gentile & Stone, 2005). Findings indicated the influence of both proximate causes (i.e., video game play) and distal factor (i.e., physiological arousal) involved in increased aggressive behavior.

The General Aggression Model shows numerous support from empirical studies, previously presented, when applied to video game research. The model's true strength applied to media research is its ability to explain the multi-faceted influences involved in the complex nature of video games. By integrating early social, cognitive, and biological theories, this framework is able to address individual differences as well as different factors involved in producing the effects of violent video games (Anderson et al., 2007).

The present study incorporates a social neuroscience approach that can be integrated as well as a distal factor in the General Aggression Model. Electrical brain potentials associated with different emotional and cognitive processes may give some insight to which neural networks are activated during game play. Continuous activation of particular networks related to aggression could be one reason why aggressive schemas are accessed easier or more dominant in response. Conversely, activation of neural networks associated with higher cognitive functions may explain why prosocial behavior is present in games with no prosocial content (Sestir & Barthalow, 2002).

Social Neuroscience. A relatively new field of study called social neuroscience has expanded within the last 20th century, with scientists utilizing a multi-disciplinary research approach to find underlying biological mechanisms such as neural, hormonal, cellular, and genetic factors that influence social behavior (Cacioppo, Bernston, & Decety, 2010). Previous research before the 20th century largely ignored social factors and neural structures. However, by acknowledging the relationships between social, psychological, and biological processes, countless new theories and paradigms about structures underlying social behavior are able to be developed.

Harmon-Jones and Winkielman (2007) outlined 3 reasons why social neuroscience is beneficial to physiological, psychological, and social fields of study with specific research examples for support. The first benefit of social neuroscience is that new theories developed are testable through empirical methods. For example, theories based on cognitive psychology, such as in the area of selective attention, have been critically assessed using evidence of support from scientific methods (Harmon-Jones & Winkielman, 2007). For example, Amodio et al. (2004) combined ideas of cognitive control from neuroscience models (Carter et al., 1998) with psychosocial models of race-bias control to show stereotyping occurred in the early stages of response execution physiologically prior to an individual's own awareness.

The second benefit to social neuroscience is that physiological measures such as heart rate variability (HRV), EEG, or skin conductance provide an unobtrusive, direct measure free from bias (Harmon-Jones & Winkielman, 2007). Behavioral measures such as self-report, questionnaires, or reaction time measures are often prone to response bias. New techniques that measure biological processes such as neural activation or muscle activation allow researchers to unobtrusively and objectively investigate psychological processes (Cacioppo, Tassinary, & Berntson, 2007). In one such case, Cacioppo and Winkielman (2001) used electromyography (EMG) to detect mild, brief positive affect facial responses in participants viewing neutral pictures (e.g., airplane, horse, dog) that were discreetly manipulated to vary ease of visual processing.

Harmon-Jones and Winkielman (2007) attributed the third benefit of social neuroscience as a means of identifying important social processes that can change brain and body functioning. One study exemplifying the relationship between social process and biology comes from Taylor et al. (2006).   Taylor and colleagues (2006) investigated the role of oxytocin, a neuropeptide implicated in stress response, in post-menopausal women. Women who experienced gaps in their social relationships such as diminished contact with friends and family or perceived to have lower spousal support had high levels of oxytocin than other post-menopausal women. They were able to confirm their hypothesis that levels of oxytocin could be used as a marker for social distress (Taylor et al., 2006).

In order to propose new theories needed to advance understanding of social brain and behavior, researchers need to develop studies that isolate social processes (Cacioppo, 2010). One major finding in neuroscience are that underlying mechanisms for aversive and appetitive stimuli activate separate in the brain (Cacioppo, Gardner, & Bernston, 1999). The processing of aversive stimuli activates an individual's *Behavioral Inhibition System* (BIS) which handles potential threat by inhibiting behavior. The second system, *Behavioral Activation System* (BAS) serves to regulate appetitive stimuli also known as cues action-oriented.   The BAS is suggested to be sensitive towards reward or engagement towards reward.   Appetitive and aversive motivation mediate a wide range of reflexes, suspected to have evolved from primitive approach and withdrawal mechanisms used to determine orienting and defense responses (Campbell, Wood, & McBride, 1997).   Simply explained, the human emotional experience that are a part of the social process can be broken down into two dimensions of the motivational system: pleasure and arousal (Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000). The motivation system is an important concept in emotion research and will be discussed later in the paper in relation to electrical brain activity. It should be noted that social neuroscience is not a substitute for behavioral or social sciences, but that it draws from those sciences to create a better understanding of brain functions during mental processes (Cacioppo, 2010). The next section will discuss the maturation of adolescent brain and how it relates to behavior.

Adolescent Brain Development Role in Emotion and Cognition

The brain consists of large networks of neurons that communicate with one another, allowing information to be processed and maintained as stored memories (Rudy, 2008). Neurons serve many functions from receiving chemical and electrical messages to sending information to other neurons (Rudy, 2008). Points in which neural communication occur are called synapses. The synaptic plasticity hypothesis proposes that the strength of synaptic connections are modifiable and necessary for learning and memory (Martin, Grimwood, & Morris, 2000). Furthermore, strength of synaptic connections are increased or decreased as a result of one's experience (Rudy, 2008), making the influence of environmental factors a topic of interest in brain development.

Developmental changes in the brain during adolescence involves neural alterations, eliminating synapses that do not perform functional links (Spear, 2007). This process of synaptic pruning is proposed to prepare the neural network for more efficient cortical processing as the brain matures. During adolescent development, there is a noticeable increase in axon myelination continued into adulthood (Sowell et al., 2003). Axon myelination is the "process by which membranous extensions of glial cells wrap protective sheaths around axons, speeding information flow along the axons (Spear, 2007, pp. 374)."

Synaptic pruning and increased myelination during adolescent development effect gray and white matter volume in areas of the brain utilized in emotion, language, and memory (Poletti, 2009). For example, one ontogenetic change that occurs is the increase in gray matter volume in the temporal lobes, amygdala and hippocampus, (Lenroot & Giedd, 2007). However, other regions of the brain tend to show decrease volume in grey matter due to synaptic pruning (e.g., frontal lobes, dorsal prefrontal cortex, parietal cortex (Sowell et al., 2001). Growth in grey matter volume in areas central to emotion and memory processing possibly reflects an increase in synapse proliferation (Blakemore & Choudhury, 2006). Researchers have an in-depth understanding of functional and structural developmental brain changes that occur during adolescence, but very little research has attempted to understand how environment influence brain development during this life stage (Blakemore, 2008). By combining behavioral theory, social neuroscience and tools to measure brain activity like electroencephalography (EEG), a greater understanding about adolescents and their social behavior may be gained.

Electroencephalography (EEG)

Electroencephalography (EEG) is one type of measurement used in social neuroscience research. EEG is a technique used to measure electrical brain activity associated with different cognitive and emotional functions (Davidson, Jackson, & Larson, 2000). Brainwaves recorded by EEG are believed to reflect inhibitory and excitatory responses associated with neuronal communication between spatially distributed brain networks (Pizzagalli, 2007).

EEG works by detecting electrical activity picked up from the scalp surface using metal electrodes generated from large populations of neurons activated synchronously

(Teplan, 2002). Due to layers of skin and skull, electrical signals are weakened when detected at the scalp surface. However, EEG technology is able to amplify and record these electrical signals. Recorded brain patterns form sinusoidal waves that reflect fluctuations in voltage (μV) from electrical signals (Libenson, 2012). Conventional algorithms are used to compute the raw EEG signals such as the Fast Fourier Transform (FFT) into power spectrum (Davidson, et al., 2000). Power spectral analysis provides researchers with information about different contributions of particular frequencies during the recording and also the amount of power yielded at each spectral band. EEG frequencies follow a grouping convention which assigns waves into different ranges or bands based on the number of peaks the sinusoidal form possesses within a 1-second period, also referred to as cycles per second (cps) or Hertz (Hz) (Teplan, 2002; Harmon-Jones & Peterson, 2009). Four peaks within 1 second is classified as a 4 Hz wave. Power, also referred to as amplitude, denotes the height of each frequency measured from peak to peak of the waveform. Detailed descriptions of EEG frequency bands will be discussed in later sections.

Electroencephalography in Adolescent Development

Due to the vast changes in brain development throughout the human life, one major determinant of electrical brain activity is the influence of age (Niedermeyer, 2005). During the early developmental stages, the delta rhythm is dominant (Knyazev, 2012). Once childhood and adolescence is reached, slow-wave EEG such as delta and theta are reduced, followed by patterns of increase in alpha and beta (Matousek & Petersen, 1973). For example, the alpha frequency tends to increase during early childhood, peaking at adulthood and then begins to decrease (Klimesch, 1999). Conversely, the increase in alpha activity appears to be related to a decrease in theta activity during development (Gasser, Verleger, Bächer, & Sroka, 1988). Beta activity over frontal areas of the brain are more widely observed in adolescents than young adults (Matoušek and Petersén, 1973; Niedermeyer, 2005). While adolescence marks a time of both biological and psychological change, there are no dramatic differences in EEG maturation between the years of 13-20. Understanding alterations in EEG maturation is important for increasing knowledge about neurophysiological functioning and creating age-standardized norms of EEG activity. Clinicians and researchers often use findings from past studies investigating EEG maturation across the lifespan (Gasser, et al., 1988) as a baseline for normal brain activity in which to compare their own data.

Electroencephalography (EEG) Frequency Bands

EEG Frequencies were named after letters of the Greek alphabet. Each band corresponding to different ranges in frequencies: *delta* (0.5 to 4 Hz), *theta* (4 to 8 Hz), *alpha* (8 to 13 Hz), and *beta* (> 13 Hz) (Teplan, 2002). The following section will discuss the different classifications of frequencies commonly used in research and psychological states commonly associated with each band found in both normal waking adults and adolescents. Different brain states may determine which frequency is more dominant during a particular time domain (Teplan, 2002). It is also important to note the presence of mixed EEG frequencies may be found in response to stimuli (Niedermeyer, 2005).

Delta. Delta waves are typically found during deeper stages of sleep (Teplan, 2002). However, during normal state of wakefulness, research has found an increase in delta EEG activity during mental tasks among adults (Harmony et al., 1996). It is suggested that delta power might be related to an increase in subjects' attention to internal processing of certain mental tasks that require discernment between the act of accepting and rejecting during performance. Similar findings have been identified in adolescents (Barry & Clarke, 2009). Lower levels of delta power were linked to problems with maintaining attention.

Theta. In adults with normal states of wakefulness, research have found correlations between a rhythmic frontal midline theta and mental activities such as problem solving (Ishihara & Yoshii, 1972; Mizuki, Takii, Tanaka, Tanaka, & Inanaga, 1982). Likewise, for the young, developing brain, low levels of theta is indicative of good cognitive performance (Klimesch, 1999), while excessive theta power also denotes attention issues (Barry & Clarke, 2009). For both adolescents and adults, theta power is related to increased mental load (Kawamata, Kirino, Inoue, & Arai, 2007; Pellouchoud, Smith, McEvoy, & Gevins, 1999; Gevins, Smith, McEvoy, & Yu, 1997), increasing in amplitude when task difficulty increases or working memory demands become higher.

Alpha. Alpha is the most dominant frequency among normal adults in a relaxed state of wakefulness (Teplan, 2002; Davidson et al., 2000). Widely studied, this frequency band is f, and other general task demands (Mulholland, 1969). Visual attention or other sensory task demands have been found to show a decrease in alpha rhythm, a process referred to as alpha desychronization (Mulholland, 1969; Ray & Cole, 1985). Cortical activation is generally believed to be related to decreased alpha rhythm (Davidson et al., 2000). Research suggests that alpha is a good indicator of cognitive and memory performance in the young and healthy, as well as in older populations

(Klimesch, 1999). Those with good memory performance tend to exhibit higher alpha frequency than those with bad performance (Klimesch, 1996, 1997).

Alpha asymmetry. For social and personality research, incongruent alpha band activation between the left and right hemisphere of the brain has revealed patterns related to motivational direction (Harmon-Jones & Allen, 1997; Rybak, Crayton, Young, Herba, & Konopka, 2006; Gable & Harmon-Jones, 2008; Davidson, et al., 1990). Motivation is described as the "energization (i.e., instigation) and direction of behavior (Elliot & Covington, 2001, pp. 73)" and can be broken down into two different systems: approach and withdrawal. Approach motivation encompasses behavior directed towards a desired event, while withdrawal motivation describes avoidant behavior to prevent the incidence of an undesired event (Elliot, 1999). Much research has found evidence indicating an association between greater left over right frontal activity and approach motivation (Peterson, Shackman, & Harmon-Jones, 2008; Verona, Sadeh, & Curtin, 2009). Moreover, greater right frontal hemispheric activity has been tied to withdrawal motivations (Harmon-Jones, 2003). This motivational direction model of frontal asymmetry (Harmon-Jones & Allen, 1998) is widely accepted by researchers (Harmon-Jones, 2003).

Emotion-related to motivational direction similarly show asymmetric hemisphere activation (Harmon-Jones, 2003; Harmon-Jones, Abramson, & Peterson, 2009); Peterson et al., 2008). For example, approach-related emotions such as anger and aggression tend to show greater left prefrontal hemispheric activation over right in the infant, adolescent, and adult brain (Fox & Davidson, 1988; Harmon-Jones & Allen, 1998; Harmon-Jones & Sigelman, 2001; Rybak et al., 2006). Emotion-related approach motivation like anger have adaptive functions, in some cases inhibiting fear and increasing one's confidence, possibly contributing energy to act towards some action (i.e., approach motivation) (Harmon-Jones & Allen, 1998). Withdrawal related emotions, such as disgust, have been found to produce more right sided activation in alpha power when experimentally induced compared to baseline levels (Davidson, Ekman, Saron, Senulis, & Friesen, 1990).

Alpha asymmetry is determined by creating an index score using the following equation: natural log right minus natural log left (ln R alpha – ln L alpha; (Coan & Allen, 2004). Asymmetric index scores are advantageous because it accounts for individual differences in skull thickness, which is highly variable during childhood (Barry & Clarke, 2009). Creating an alpha asymmetry index is also advantageous for a host of other methodological issues such that it makes statistical tests more sensitive by reducing number of contrasts and increasing statistical power, has been adopted as an efficient analytic tool (especially if hemispheric analyses are included), and shows high internal consistency and acceptable test-retest reliability (Coan & Allen, 2004). For the following aforementioned reasons, an alpha asymmetry index will be computed for each individual in the study to examine hemispheric differences.

Beta. Between 13 Hz to 35 Hz, beta activity reflects activation of the cortex and should increase with cognitive demands related to task requirement (Sherlin, Budzynski, Budzynski, Evans, & Abarbanel, 2008). It has also been associated with increased levels of concentration, beta being the predominant band present as level of task engagement and challenge rises (Sherlin et al., 2008). In adolescents, higher beta represents more active processing (Ackerman, McPherson, Oglesby, & Dykman, 1998). Children deficits in attention and hyperactivity show low beta activity (Bresnahan, Anderson, & Barry, 1999; Hobbs, Clarke, Barry, McCarthy, & Selikowitz, 2007; Lazzaro et al., 1999).

Research with EEG Measures during Video Game Play

While the effects of video games have been under investigation since the 1980's (Anderson et al. 2010), the literature concerning video game play and its influence on adolescent brain activity using quantitative EEG measures are sparse. After an extensive literature search, only three studies were found, mainly looking at the theta wave band. For example, Pellouchoud and colleagues (1999) looked at video game influences in 14 children between ages of 9-15 years; seven of the participants had been diagnosed with seizure disorder. EEG was recorded while children played their choice of six Super Nintendo games, information on specific games or game genres were not given. There were no significant differences between children with epilepsy and those without. All participants showed increased frontal midline theta and decreased alpha with increased mental load manipulated by being in one of three conditions: resting, watching the game, and playing. Results from this study substantiated findings from previous research involving video games have also detected increased levels of frontal midline theta during play by children ranging from 8-15 years old (Yamada, 1998).

In a more recent video game study, theta activity continues to consistently appear during game play. One pilot study investigated theta activity in four young, healthy humans playing a competitive and a strategy game video game for 2 hours (He, Yuan, Yang, Sheikholeslami, & He, 2008). Frontal midline theta activity was found to increase over time compared to collected eyes open baseline data. The longer participants played, the larger the frontal theta wave. Frontal theta waves were also larger for strategy game compared to the competitive game, which could represent increased resources and mental load on players dependent on game content. He and colleagues (2008) suggest possible mental health implications.

Theta band activity has also been isolated in video game research assessing the cortical activity associated with motor coordination used to move in the virtual environment (Baumeister, Reinecke, Cordes, Lerch, & Weis, 2010). Researchers assessed cortical activation using real and virtual environmental task of putting in golf in young adults (26 ± 7 years). Virtual movement was evaluated as participants played a Wii video golfing game. Heightened frontal theta power in the were found during both real and virtual putting environment performances, suggesting both conditions required increased concentration compared to the resting period. Theta with increasing working memory load, task difficulty and mental effort which was described as closely related to focused attention (Gevins et al., 1997).

Since a major concern with video games has been its relationship to attention problems in young children (Gentile et al., 2009; Swing et al., 2010) it is not surprising that the few studies using quantitative EEG to investigate game play focused mainly on theta activity because of its correlation to mental load and attention (Klimesch, 1999; Barry & Clarke, 2009). However, quantitative EEG may offer additional information on brain activity related to the player's emotional, attentive, and arousal state through the investigation of different band activity such as delta, alpha, and beta.

Researchers, Salminen and Ravaja (2007, 2008) have begun this investigation into various band activity and possible associations related to game events (Salminen & Ravaja, 2007, 2008). In their 2007 study, Salminen and Ravaja found distinct differential

EEG responses elicited by game events in Super Monkey Ball 2, a game involving the navigation of a monkey in a ball through a maze, whose goal is to pick up bananas for points and avoid falling off the edge of the game board to reach the end point. Twenty-five healthy young adults between the ages of 20 to 30 years playing this game revealed increased theta activation and increased beta while picking up bananas. This activity suggested that required concentration and attention was necessary to perform the task successfully, especially since the bananas were placed in difficult to reach places on the game board (Salminen & Ravaja, 2007). When players fell off the raised game board, EEG activity evoked a greater left compared to right hemispheric response possibly indicating some approach oriented emotion. At the event where players completed the maze and reached the end point, there was an increase in theta, alpha, and beta activation. Theta and alpha activations were suggested to reflect a state of momentary relaxation, before the next level of game play began and beta activation was attributed to electrical activity related movement required for game play.

In a second study, Salminen and Ravja (2008), aimed to investigate EEG responses when game players engaged in violent, virtual events. Twenty-five healthy young adults between 20 to 30 years of age, played three 5-minute game sessions in which their mission was to defeat the enemy with various weapons such as pistols, assault rifles, etc. EEG recordings were tied to specific game events when the player wounded the opponent and when the player killed the opponent in the game. Central alpha activation was detected over motor areas of the brain, most likely due to finger movements needed to engage in game play. Wounding and killing the opponent also elicited increased occipital theta activation. This was suggested to reflect increased concentration to complete the task at hand and possibly processing of violent game events. The visual cortex of the brain is observed in occipital regions of the brain and previous research have found similar activation in subjects viewing emotional stimuli (Aftanas, Reva, Varlamov, Pavlov, & Makhnev, 2004; Krause, Viemerö, Rosenqvist, Sillanmäki, & Åström, 2000). Furthermore, increased theta at electrodes placed in the occipital areas of the scalp was not present in previous video game investigations involving non-violent game events (Salminen & Ravaja, 2007).

A previous study similar to the current investigation was conducted by Lianekhammy and Werner-Wilson (2012) with college-aged students. Forty-five participants were randomly assigned to either a violent, non-violent, or brain training game. EEG was recorded during game play. Results revealed increased frontal theta activation in the brain training group only, which was proposed to indicate a specificity in type of content necessary to elicit frontal theta response. Frontal asymmetric activity was found; violent game participants exhibited greater left than right alpha activation. Numerous research have linked this type of activation with approach-related emotions such as aggression (Davidson, et al., 2000) and behavioral research have shown violent video games lead to increased cognition and emotion (Anderson, 2004, Anderson, et al., 2010).

To the best of our knowledge, no further research to date has investigated cortical responses to video game play in adolescents using quantitative EEG. The aim of this study is to gain a better understanding of adolescent brain activity during violent, non-violent, and brain training video game play. By understanding what electrical responses occur in the brain at the time of game play, researchers may better postulate the various influences of video games on adolescent brain development, therefore leading to new theories or strengthening of existing theories to explain linked behaviors associated with game play. Based on previous behavioral and physiological studies involving video games, the following research questions and hypotheses are proposed.

Research Question 1: Is there a relationship between prosocial personality and hours of video games played per week?

Hypothesis 1: Participants with lower prosocial personality spend more time playing video games on a weekly basis.

Research question 2: Is there a relationship between grade point average and hours of spent playing video games per week?

Hypothesis 2: Participants with lower grade point averages spend more time playing video games on a weekly basis.

Research Question 3: Is there a relationship between low attention, hours spent playing video games per week, and electrical brain activity in adolescents?

Hypothesis 3: Participants that heavily play video games weekly will have lower attention measures and lower levels of delta and beta activity, which is implicated in attention deficits, in baseline conditions (prior to game play).

Research Question 4: Will violent game play evoke differential brain activity distinctly evoked by graphic content compared to the non-violent and brain training groups?

Hypothesis 4a: Occipital theta activation will be significantly higher than baseline conditions for the violent gaming group, compared to the non-violent and violent group reflecting mental processing of graphic content (i.e., blood, death).

Hypothesis 4b: Greater left than right alpha activation will be more prominent in the violent group possibly associated with approach related emotions such as aggression or anger commonly associated with violent video games.

Research Question 5: Since the brain training game involves problem solving and memory tasks, will participants in this group show unique brain activity compared to the violent and non-violent game?

Hypothesis 5: Participants in the brain training group should exhibit increased alpha frequency, indicative of good cognitive and memory performance compared to violent and non-violent games. Violent and non-violent games, both highly visual games, should show decreased alpha synchronization.

Research question 6: Will electrical brain activity increase the longer an adolescent plays a video game due to mental effort required for performance?

Hypothesis 6: It is hypothesized that frontal midline theta, linked to mental effort and increased attention, will increase in amplitude as a function of time in all gaming experiences: violent, non-violent, and brain training. The brain training game should show higher frontal midline theta activation than the violent and non-violent game because of higher cognitive demands in task performance.

Chapter Three

Methodology

Participants

A convenience sample of adolescents between the ages of 13-17 (*M*=14.3 years, *SD*=1.5) were recruited by placing fliers throughout the University of Kentucky campus, local businesses, and local churches in Fayette and Woodford County. For adolescent participant recruitment, discussion and scheduling appointments for the study was conducted only with a parent/guardian of the child. It was made clear that a parent/guardian must be present throughout the entire study. The study aimed to only recruiting children with interest in participating in the study. This was emphasized to the parent/guardian to prevent parental pressure or coercion. Forty-five adolescents (32 male, 13 female) with normal or corrected to normal visual acuity of 20/40 or better participated in the study. No history of seizures, epilepsy, or symptoms linked to epileptic conditions (e.g., loss of awareness) were reported. No prior experience with video games was required, though many of the children had experience and reported playing an average of 10.7 hours weekly (SD=12.4). Individuals received of $40 as compensation for their time and participation.

Video Games

All games were played with the Wii (Nintendo Co., Ltd., Kyoto, Japan) gaming console with the standard controller except for participants playing *Medal of Honor: Heroes 2*. Participants playing *Medal of Honor* used the Wii Zapper, an accessory which allows the standard controller to be converted into a gun. All games were set to a beginner's setting, although the difficulty level increased as the players were more successful in completing game levels.

Medal of Honor: Heroes 2. This first person shooter perspective game, was chosen as the violent game because it contained acts of aggression and violence, but was still age appropriate for the study sample. *Medal of Honor*: *Heroes 2* has the ESRB Rating "Teen" (appropriate for individuals 13 years and older) which states that titles rated **T (Teen)** have content that may be suitable for ages 13 and older, but may contain violence, suggestive themes, crude humor, minimal blood, simulated gambling, and/or infrequent use of strong language. Players in this game are given a controller simulated gun and asked to complete the mission while avoiding enemy forces. Players must shoot and kill opposing forces in order to complete the mission successfully.

Super Monkey Ball Banana Blitz. This non-violent game was chosen based on the similarity to the game played in Salminen and Ravja's (2007) research. Since little research has explored various frequency bands during game play, it was of interest whether comparable types of activation would be found in the current study. The game consists of players navigating a monkey in a ball through a colorful and playful raised game board environment. The player must move through a maze without falling over the edge while completing tasks such as picking up bananas and avoiding obstacles. ESRB rated this game as E for Everyone, making it suitable for ages 6 and older. E rated games are noted to contain minimal cartoon, fantasy or mild violence and/or infrequent use of mild language, though Super Monkey Ball did not appear to contain instances of violence as a requirement in game play.

Wii Degree: Big Brain Academy. The brain train game engages players in several mini-games that are designed to measure/enhance memory, analysis, number crunching, and visual recognition. Participants were given a grade after each mini-game (e.g., A-, B, C+) which encouraged players to perform to the best of their abilities. This game was also rated E for Everyone, and did not contain any instances of violence.

Questionnaires and Measures

Demographic Questionnaire. Basic information was collected about the participant's age, gender, ethnicity, hours of video games played per week and types of preferred video games. This information was collected to gain a better idea of the adolescents experience with games and to gauge what types of games they enjoyed playing. See Appendix A for a sample questionnaire.

Educational Attainment Questionnaire. Children were asked to complete a short questionnaire regarding the type of school they were currently attending (i.e., Public, Non-Religious Private, or Montessori), current grade level, and their grade point average for their most recent semester. Grade point average was obtained to understand the relationship with hours of video games played per week in this sample (Appendix B).

Measure of Visual and Auditory Attention. Participants completed the IVA+Plus, a computerized auditory and visual attention assessment prior to and after game play. The IVA+ was designed to diagnose ADHD in children, adolescents and adults by measuring the person's ability to concentrate and to avoid making impulsive errors. The assessment lasts approximately fifteen minutes and consists of trials of "1's" and "2's"s presented visually on the computer screen or spoken by a narrator. The individual is directed to click the computer mouse whenever he/she sees or hears a "1" and asked to ignore any presentation of the number “2.” Participants are given practice time, built into the program, prior to the main task.

The IVA+Plus provides numeric response and attention quotient scores. *Response Control Quotient Scores* is derived from scores on three separate measures: prudence, consistency, and stamina. Prudence is defined as impulsivity and response inhibition and is reflected through false responses or not responding when one should. Consistency measures one’s ability to stay on task and stamina is based on the individual’s sustained attention and effort over a specified length of time. *Attention Quotient Scores* is the combined information from vigilance, focus, and speed scores. Vigilance determines level of inattention, focus represents mental processing speed for correct responses and speed refers to the reaction time for all correct responses. Speed scores are able to discriminate between attention problems and slow mental processing.

Measure of Prosocial Personality. Participants completed the Prosocial Personality Battery (Penner, 2002) after video game play (Appendix C). The Prosocial Personality Battery (Penner et al., 1995) comprises of 2 total scores capturing Helpfulness and Other-Oriented Empathy. Empathy is thought to mediate prosocial tendencies (Batson, 1991; Davis, 1994) and reflects prosocial thoughts and feelings directed to feeling responsible for other’s welfare. Helpfulness reflects the likeliness to help others in distress and primarily measures behavioral tendencies. The Prosocial Personality Battery has been found to be a reliable predictor of prosocial behavior (Penner & Fritzche, 1993; Penner & Finkelstein, 1998).

The scale consists of 30-items comprised of individual scales in the areas of: social responsibility (α=0 .65), empathic concern (α=.67), perspective taking (α=.66), personal distress (α= .77), mutual moral reasoning (α=.64), other oriented reasoning (α= .77), and self-reported altruism (α=.73). The scale consists of questions such as "I sometimes find it difficult to see things from the "other person's" point of view" or "When you have a job to do, it is impossible to look out for everybody's best interest." Participants will be asked to answer using a Likert scale system from "Strong Disagree," "Disagree," "Uncertain," "Agree," or "Strongly Agree." The Prosocial Personality Battery took approximately 10-minutes to complete.

Procedures

Upon arriving for the appointment, participants were given a brief eye exam to make sure their vision was within normal range. The parent/guardian was then given the informed consent and asked to read over it. Likewise, the adolescents were given an assent form to read over and were encouraged to ask questions about the study. Once consent was given, a research assistant explained the IRB with the participants to make sure all parts are clear. Participants were reminded that this is all volunteer basis and they may stop at any time. Next, self-report questionnaires for collecting demographic information and educational information were filled out, followed by completion of the visual and auditory assessment (IVA+).

Once the assessment was completed, a research assistant attached an electrode cap and sensors to the participant's wrists/arms that measured physical and mental arousal. Throughout this time, research assistants describe each step as hooked up the equipment so that the participant was aware of the procedure. Once the electrode cap and sensors was hooked up, baseline data was collected in which the participant sat with their eyes open, and closed for 5 minutes. After baseline data was collected, participants to played one of three games: *Super Monkey Ball*, *Medal of Honor*, or *Wii Degree: Big Brain Academy*. Participants placed their chin in a chin rest to prevent excessive movement during EEG recording and were told notify the assistant anytime to take a break at any time. At the end of the 20 minute game play, participants finished up the study by taking a 30-item Prosocial Personality Battery.

EEG Measures

EEG was recorded using The NeXus-32 (Mind Media, The Netherlands) to measure electrical brain activity. The Nexus-32 measures 24 channels of EEG data (true DC), SCP (slow cortical potential), and eye movement obtained at a 2048 Hz sampling rate at a 24-bit resolution. Data was collected using an EEG electrode cap that included Ag/AgCL electrodes manufactured by Medi Factory (Nieuwkoop, The Netherlands). The electrode cap is a lycra-stretch cap affixed with 16, 32, 64, or 128 electrodes used as electrical potential sensors (Thakor & Tong, 2004). It is the traditionally used to record brain activity (Harmon-Jones & Peterson, 2009).

Based on the 10-20 electrode system (Jasper, 1958), each electrode on the cap follows a placement and naming convention which correspond to the brain region for which the electrode is positioned over. Electrodes are designated by letters and numbers. If the electrode begins with the letter F, its placement is over the frontal region of the brain, while electrodes beginning with Fp are placed over the frontal pole region. Electrodes labeled C correspond to the central region, P refers to the parietal areas of the brain, T the temporal region, and O is placed over the occipital area of the brain. Electrodes placed between the left and right side of the brain, directly on the midline are noted by the letter z (e.g., (Fz, Cz, Pz, Oz). Odd numbers designate areas to the left side of the head and even numbers refer to areas on the right side of the head (e.g., F3, F4). Most electrode caps also include a ground electrode which helps reduce electrical noise (Harmon-Jones & Peterson, 2009). The ground electrode on the caps used for the current study was located in midline position on the cap between the frontal pole and the frontal site. The reference electrode was located on the cap at the left and right mastoid. Linked-ears reference was applied off-line. All electrode impedances were under 25,000. All electrodes (i.e., FP1, FP2, F3, F4, F7, F8, Fz, C3, C4, Cz, T3, T4, Pz, O1, and O2) were used in data analysis. See Figure 3.1 for an example of electrode positioning.

Data was exported from proprietary NeXus software to Neuroguide for data analysis. Semi-automatic artifact rejection of bad data was completed, while the remaining good data was manually artifacted to ensure all segments of unusable data (e.g., eye blinks, head movement during the study, or equipment malfunction) were removed. Artifacts in the data represent picking up electromyography (EMG) or eye blinks, also referred to as muscle artifacts, recorded along with EEG signals. Muscle artifacts are typically of higher frequencies than EEG signals and contaminate data. Muscle movement is unavoidable during EEG recording, so it is necessary to remove artifacts during the data-processing stage (Harmon-Jones & Peterson, 2009).
For this study, comparisons were made with the normative sample database of data from lifespan (birth to age 82) norms, available through Neuroguide. Fast Fourier transform (FFT) was use to derive artifact-free power estimates (μV^2) for specific frequency bands: delta (1-4 Hz), theta (4-8 Hz), alpha (8-13 Hz), and beta (13-20 Hz) (Harmon-Jones & Peterson, 2009).

Statistical Analysis

Basic demographic information were analyzed to compare and contrast each of the game groups (i.e., violent, non-violent, and brain train). A one-way analysis of variance (ANOVA) was calculated for continuous variables: age, grade point average, hours of reported video game play, and baseline absolute power values for all bands (i.e., delta, theta, alpha, and beta) at all electrode sites. A chi-squared test of independence were used to analyze nominal variables gender and race. Seven participant's EEG contained recordings with unusable data for various electrodes FP1, FP2, F3, F4, F7, F8, Fz, C4, Cz, T5, T6, Pz, O1, and O2 due to excessive artifact. Mean power for unusable electrodes were excluded from all analyses involving those sites. The following analyses were conducted to investigate the each of the research questions.

Bivariate correlations using Pearson's r were used to identify the relationship between prosocial personality and hours of video games played per week, as well as investigate the relationship between grade point average and hours of game play reported. A multiple linear regression analysis was used to determine if predictor variables: attention as measured by IVA+ quotient scores (Response Control and Attention) and hours spent playing video games were related to specific brain activation in absolute delta, theta, alpha, or beta frequency, the dependent variables. Independent variables, age, gender and grade point average (GPA), were also included in the model to control for possible influences.

The statistical analyses focused on group differences involving different types of video games used repeated measures Analysis of Variance (ANOVA). Group (violent, non-violent, brain train) by Condition (baseline, game play) were analyzed separately for delta, theta, alpha, and beta frequency bands. To investigate whether brain activation increases over the course of video game play in response to increased mental load, EEG from the 20-minute game session was segmented into 4 time periods, each 5-minutes long. Designs with three or more levels of repeated measures are vulnerable to violating assumptions of sphericity needed for repeated measures analysis, but rarely met with psychophysiological data (Vayer & Thayer, 1987). Per recommendations of Vasey and Thayer (1987), a Multivariate Analysis of Variance (MANOVA) was used to compensate for possible violation. This approach has been used reliably by other researchers investigating EEG activity and alpha hemispheric differences (Coan, Allen, & Harmon-Jones, 2001). A MANOVA was used to investigate a Group x Time (Baseline, Time 1, Time 2, Time 3, and Time 4) effect for frontal electrodes within the theta frequency and alpha asymmetry index scores. Alpha asymmetry index scores were used to determine the presence of asymmetric activation between hemispheres among participants of different groups during game play using and calculated with the formula: natural log right minus natural log left (ln R alpha – ln L alpha; (Coan & Allen, 2004). Post-hoc analysis were conducted for all significant findings using Tukey's test.

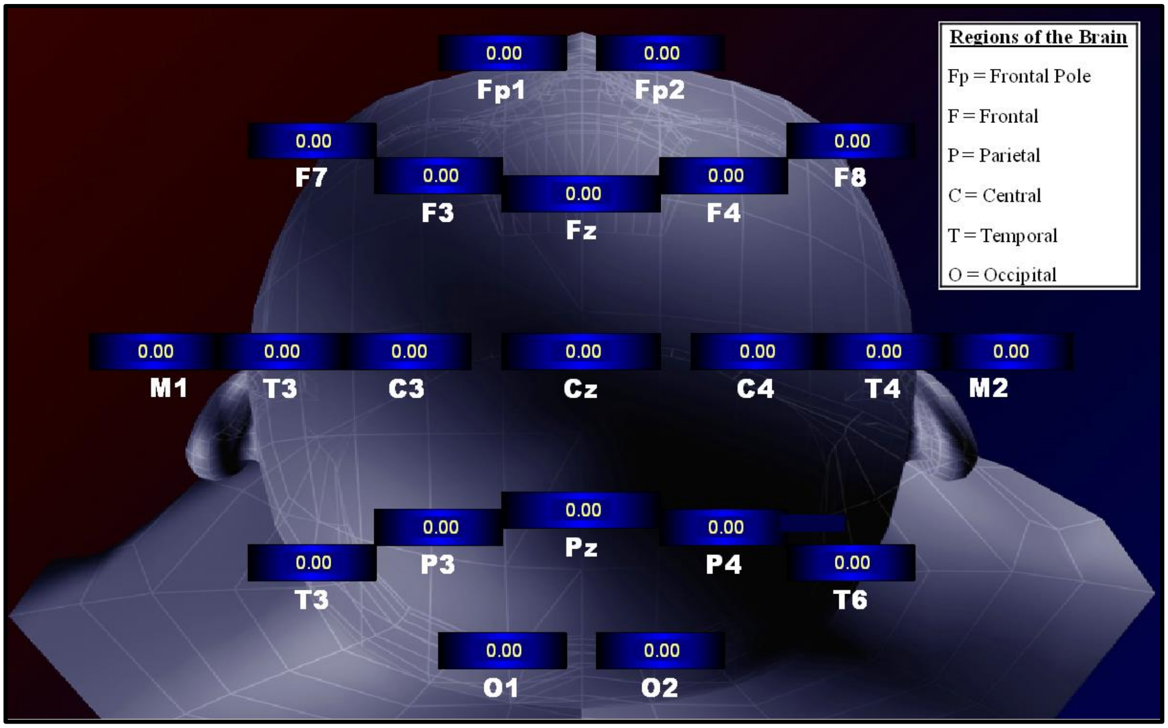

Figure 3.1. Graphic representation of a 21-channel electrode placement. M1 and M2 electrodes were used as reference points. The zero value indicates initial value prior to signal detection.

Chapter Four

Results

Descriptive Statistics

A one-way ANOVA was computed to compare age, grade point average (GPA), hours of reported video game play between the participants in each video game group, violent, non-violent, and brain train. A main effect of reported game play per week was found between the three groups ($F(2,42) = 4.67$, $p < .05$). Post hoc comparisons indicated significant differences between reported hours of game play by the violent game groups compared to brain train group ($p < .05$). It should be noted that two participants in the violent group reported relatively high amounts of game playing during the week of 49 and 58 hours, inflating the group's mean. No other group differences in age or GPA was found. A chi-squared test of independence was conducted looking at gender and race between groups and no significant differences were found. Table 4.1 provides a breakdown of each variable with group averages and percentages.

Relationships between Game Play, Prosocial Personality and Academics

Two participants completed the Prosocial Personality Battery questionnaire, but was believed to have inadvertently missed answering one of the questions. Instead of excluding that participant, the average response of the section skipped was used in place of the missing data. There were significant a significant negative correlations between hours of reported game play per week and both factors representing prosocial tendencies, Other-Oriented Empathy (r= -.480, N=45, $p < .001$, one-tailed) and Helpfulness (r= -.305, N=45, $p < .05$, one-tailed). For Other-Oriented Empathy scores, there was a moderate correlation with the amount of game play adolescents reported playing during the week: 23.0% of the variation explained. Figure 4.1 shows a scatterplot of data points for amount of game play and Other-Oriented Empathy scores. Helpfulness scores showed a weaker correlation to time spent playing video games, explaining only 9.3% of the variance (See Figure 4.2 for scatterplot of data points). Bivariate correlations between GPA and time spent game playing was not significant, but was approaching significance (r= -.248, N=44, p=.055, one-tailed).

Relationship between Attention and Game Play

Results of the multi-linear regression revealed predictor variables for attention and hours of game play did not account for any significant variance in activation from any of the 19 electrodes at all frequency bands, delta, theta, alpha, and beta (p >.05). However, age, gender, and grade point average were significant factors (p<.05) in the model for several electrodes in the delta, alpha, and theta frequency bands. Table 4.2 through Table 4.6 provides a summary of the model statistics for each significant electrode at the specified band.

Brain Activation in Violent Game Play

Activation for absolute theta power was investigated for group differences from baseline to game play in occipital areas of the brain (O1, O2). A repeated measures ANOVA showed no significant main effect of group or interactions between group and condition (baseline, game play) for O1 electrode (F(2, 41)=.031, p>.05) . For electrode O2, a main effect of condition was significant (F(2, 41)=6.327, p<.05). Theta power increased during video game play (M=10.53, SD=5.04) from resting baseline (M=9.36, SD=5.14).

Asymmetric hemisphere activation was also studied comparing alpha asymmetry index scores between groups with a MANOVA for electrode pairs: FP1 and FP2, F3 and F4, and F7 and F8 at different points of the gaming session. Resting frontal asymmetry index scores were also included in the analyses to detect differences between groups at baseline and no significant differences were found at baseline between groups indicating similar asymmetry index scores. Asymmetric index scores were compared for between groups during the game playing condition at Time 1, Time 2, Time 3, and Time 4. Box's test of equal covariance was not significant, signifying equal covariance of the dependent variables across groups (p=.068). Therefore, Wilks' Lambda was used. Results indicated significant hemispheric differences between groups only for electrode pair F3 and F4, ($F(2, 41) = 1.96$), $p<.05$). See Figure 4.3 for graphs of natural log power values in F3 and F4 over the course of video game play. Between subject effects were significant for Time 1, the first five minutes of game play ($F(2, 41)=3.97$, $p<.05$, $\eta^2=.162$), Time 2 representing 5-10 minutes into game play ($F(2,41)=6.82$, $p<.01$, $\eta^2=.250$), and Time 4 which captures play time 15-20 minutes into the game ($F(2,41)=6.68$, $p<.01$, $\eta^2=.246$). Levene's Test of Equality of Error Variances revealed equal error variances in the dependent variables across groups were present for Time 2 and Time 4 variables, but not for Time 1 ($F(2,41)=3.96$, $p<.05$). For this reason, post hoc comparisons for Time 2 and 4 were completed using Tukey's test of multiple comparison, while the post hoc for Time 1 was completed using Tamhane's test, appropriate because equal variances are not assumed.

Tamhane post hoc tests suggested that at Time 1, alpha asymmetry was significantly different for those in the violent game group than those in the brain training group ($p<.05$), showing greater right hemisphere activation. For both Time periods 2 and 4, Tukey's test results revealed violent game group participants significantly showed greater right hemisphere activation compared to both non-violent ($p<.05$)and brain training groups ($p<.001$). Table 4.5 provides mean difference scores for all post hoc analyses.

Contrasts between resting baseline and time intervals 1-4 were completed to identify if a main effect of time was present. A significant difference in asymmetry index for FP1 and FP2 was found ($F(1,40)=5.170$, $p<.05$) between the resting baseline and time interval 3. The asymmetry index went from 0.0329 (SD=.09) to -.0068 (SD=.09) during the 10 to 15 minutes of game play, suggesting a shift from greater right to left hemisphere activation. For electrode pair F3 and F4, alpha index was significantly different ($F(1,41)=8.729$, $p<.01$) between Time 1 (M=.0515, SD=.12) and Time 3 (M=.0357, SD=.12), also showing a difference ($F(1,41)=4.202$, $p<.05$) between Time 2 (M=.0085, SD=.11) and Time 3. Asymmetric activation appeared to shift more towards the left hemisphere the longer game play continued. For electrodes F7 and F8, the only significant difference ($F(1,40)=5.619$, $p<.05$) in asymmetry was between Time 1 (M=.0537, SD=.21) and Time 3 (M=.0011, SD=.20).

Alpha Activation in Problem Solving and Memory Tasks

There was a main effect of condition ($p<.01$), for electrodes positioned in frontal, parietal, temporal and occipital areas of the brain (FP1, FP2, F3, F4, F7, F8, Fz, P3, P4, Pz, T3, T4, T5, T6, O1, O2). Alpha power decreased from baseline to game play. Table 4.6 provides mean voltage and other statistical details for each finding. Covariance was not equal across groups so Pillai's Trace test was used. A group by condition interaction was present for FP2 ($F(2, 40)=3.58$, $p<.05$). Post hoc analyses indicated that baseline alpha power decreased in game playing for those in the violent game group ($F(1,14)=11.00$, $p<.01$) and the non-violent game group ($F(1,14)=8.19$, $p<.05$). In violent game group, mean baseline alpha power was 9.05 ($SD=3.38$) and decreased to 7.20 ($SD=2.28$) during game play. The non-violent game group showed a similar pattern of electrical desynchronization, with a mean baseline of 12.37 ($SD=7.30$) and 7.71 ($SD=2.04$) mean power value at game play.

Brain Activity over the Course of Game Play

Results of a MANOVA for theta power revealed no significant interaction or group effects between frontal theta activation between the four different time intervals ($p>0.05$). Planned comparisons looked at possible differences between each intervals. Significant differences were found only at electrodes site F8 between Time 1 vs. Time 3 ($F(1,40)=7.334$, $p<.01$) and Time 2 vs. Time 3 ($F(1,40)=6.164$, $p<.05$). Theta power decreased at Time 3 ($M=11.63$, $SD=4.19$) compared to Time 1 ($M=12.23$, $SD=4.59$) and Time 2 ($M=12.21$, $SD=4.61$).

Table 4.1

Descriptive Statistics for Participants by Video Game Condition

	Brain Train Game (*n*=15)	**Violent Game** (*n*=15)	**Non-Violent Game** (*n*=15)
Age	14.9 yrs (*SD*=1.5)	14.8 yrs (*SD*=1.5)	14.53 yrs (*SD*=1.5)
Gender			
Male	10 (66.7%)	9 (60.0%)	13 (86.7%)
Female	5 (33.3%)	6 (40.0%)	2 (13.3%)
Race			
Caucasian	11 (73.3%)	10 (66.7%)	8 (73.3%)
African-American	3 (20.0%)	4 (26.7%)	5 (33.3%)
Asian	1 (6.7%)	1 (6.7%)	1 (6.7%)
Other	0 (0%)	0 (0%)	1 (6.7%)
Hours of Game Play per Week	4.8 hrs (SD=10.6)	17.7 hrs (SD=17.4)*	9.3 hrs (SD=8.4)
	n=14	n=14	n=15
GPA	3.5 (SD=0.6)	3.3 (SD=0.7)	3.2 (SD=0.7)

Note. Some participants were unsure of their GPA for the most recent semester and were unable to provide that information.
*$p<.05$.

Table 4.2

Regression Coefficients for Significant Delta Frequency Models by Electrode

Electrode	Adjusted R^2	Variable	β	*t*	*p*
F3	0.326	GPA	.400	2.473	.019
		Age	-.472	-3.265	.003
		Gender (Female = 1)	-.343	-2.369	.024
		Hours Game play	-.129	-.905	.372
		IVA+ Response Control	.090	.559	.580
		IVA+ Attention	-.204	-1.159	.254
F4	.324	GPA	.410	2.532	.016
		Age	-.441	-3.048	.004
		Gender (Female = 1)	-.425	-2.930	.006
		Hours Game play	-.142	-1.000	.324
		IVA+ Response Control	.128	.793	.433
		IVA+ Attention	-.262	-1.489	.146
F7	.236	GPA	.473	2.731	.010
		Age	-.278	-1.796	.081
		Gender (Female = 1)	-.238	-1.501	.143
		Hours Game play	-.060	-.391	.698
		IVA+ Response Control	.106	.628	.534
		IVA+ Attention	-.098	-.526	.602
C3	.264	Age	.350	2.078	.045
		Gender (Female = 1)	-.500	-3.323	.002
		GPA	-.319	-2.098	.043
		Hours Game play	-.025	-.168	.868
		IVA+ Response Control	.063	.382	.705
		IVA+ Attention	-.248	-1.362	.182

Table 4.2 (Continued)

Electrode	**Adjusted R^2**	**Variable**	**β**	***t***	***p***
C4	.268	Age	.327	1.926	.063
		Gender (Female = 1)	-.516	-3.441	.002
		GPA	-.386	-2.530	.016
		Hours Game play	-.073	-.494	.625
		IVA+ Response Control	.063	.365	.718
		IVA+ Attention	-.274	-1.501	.143
P3	.344	Age	.448	2.813	.008
		Gender (Female = 1)	-.478	-3.367	.002
		GPA	-.492	-3.427	.002
		Hours Game play	-.149	-1.072	.291
		IVA+ Response Control	.025	.160	.874
		IVA+ Attention	-.297	-1.732	.092
P4	.215	Age	.385	2.212	.034
		Gender (Female = 1)	-.395	-2.544	.016
		GPA	-.487	-3.101	.004
		Hours Game play	-.079	-.521	.606
		IVA+ Response Control	-.016	-.092	.927
		IVA+ Attention	-.340	-1.812	.079
O2	.139	Age	.435	2.381	.023
		Gender (Female = 1)	-.288	-1.755	.088
		GPA	-.365	-2.190	.035
		Hours Game play	-.144	-.895	.377
		IVA+ Response Control	.051	.287	.776
		IVA+ Attention	-.252	-1.291	.205
T3	.293	Age	.358	2.164	.037
		Gender (Female = 1)	-.371	-2.513	.017
		GPA	-.507	-3.405	.002
		Hours Game play	-.133	-.919	.364
		IVA+ Response Control	.207	1.285	.207
		IVA+ Attention	-.260	-1.461	.153

Table 4.2 (Continued)

Electrode	**Adjusted R^2**	**Variable**	**β**	***t***	***p***
T4	.265	Age	.296	1.756	.088
		Gender (Female = 1)	-.402	-2.670	.011
		GPA	-.391	-2.577	.014
		Hours Game play	.054	.367	.716
		IVA+ Response Control	.226	1.374	.178
		IVA+ Attention	-.211	-1.164	.252
T6	.182	Age	.367	2.001	.053
		Gender (Female = 1)	-.310	-1.953	.059
		GPA	-.493	-2.997	.005
		Hours Game play	-.048	-.303	.764
		IVA+ Response Control	.107	.585	.562
		IVA+ Attention	-.318	-1.535	.134
Fz	.308	Age	.403	2.455	.019
		Gender (Female = 1)	-.445	-3.042	.005
		GPA	-.335	-2.288	.028
		Hours Game play	-.148	-1.026	.312
		IVA+ Response Control	.080	.489	.628
		IVA+ Attention	-.175	-.983	.333
Cz	.300	Age	.287	1.736	.092
		Gender (Female = 1)	-.532	-3.612	.001
		GPA	-.400	-2.710	.010
		Hours Game play	-.078	-.540	.593
		IVA+ Response Control	.081	.491	.627
		IVA+ Attention	-.224	-1.252	.219
Pz	.324	Age	.361	2.227	.033
		Gender (Female = 1)	-.496	-3.425	.002
		GPA	-.443	-3.052	.004
		Hours Game play	-.093	-.653	.518
		IVA+ Response Control	-.005	-.028	.978
		IVA+ Attention	-.152	-.865	.393

Table 4.3

Regression Coefficients for Significant Theta Frequency Models by Electrode

Electrode	Adjusted R^2	Variable	β	*t*	*p*
F3	.175	Age	.332	1.853	.073
		Gender (Female = 1)	-.423	-2.643	.012
		GPA	-.235	-1.465	.152
		Hours Game play	-.079	-.501	.620
		IVA+ Response Control	-.066	-.370	.713
		IVA+ Attention	-.063	-.324	.748
F7	.223	Age	.401	2.297	.028
		Gender (Female = 1)	-.407	-2.607	.013
		GPA	-.288	-1.804	.080
		Hours Game play	-.129	-.843	.405
		IVA+ Response Control	.048	.283	.779
		IVA+ Attention	-.159	-.849	.402
C3	.277	Age	.345	2.067	.046
		Gender (Female = 1)	-.532	-3.565	.001
		GPA	-.296	-1.965	.057
		Hours Game play	.013	.089	.930
		IVA+ Response Control	-.100	-.616	.542
		IVA+ Attention	-.129	-.719	.477
C4	.248	Age	.353	2.051	.048
		Gender (Female = 1)	-.535	-3.518	.001
		GPA	-.332	-2.146	.039
		Hours Game play	-.067	-.444	.660
		IVA+ Response Control	-.150	-.856	.398
		IVA+ Attention	-.148	-.800	.429
P3	.344	Age	.458	2.878	.007
		Gender (Female = 1)	-.488	-3.433	.002
		GPA	-.454	-3.168	.003
		Hours Game play	-.140	-1.010	.319
		IVA+ Response Control	-.159	-1.022	.314
		IVA+ Attention	-.149	-.867	.392

Table 4.3 (Continued)

Electrode	Adjusted R^2	Variable	β	*t*	*p*
P4	.322	Age	.429	2.652	.012
		Gender (Female = 1)	-.495	-3.428	.002
		GPA	-.494	-3.389	.002
		Hours Game play	-.121	-.855	.399
		IVA+ Response Control	-.190	-1.201	.238
		IVA+ Attention	-.230	-1.321	.195
O1	.291	Age	.494	2.975	.005
		Gender (Female = 1)	-.360	-2.417	.021
		GPA	-.530	-3.500	.001
		Hours Game play	-.195	-1.330	.192
		IVA+ Response Control	-.003	-.020	.984
		IVA+ Attention	-.274	-1.548	.131
O2	.385	Age	.460	2.976	.005
		Gender (Female = 1)	-.484	-3.486	.001
		GPA	-.569	-4.037	.000
		Hours Game play	-.137	-1.001	.324
		IVA+ Response Control	-.018	-.122	.904
		IVA+ Attention	-.271	-1.641	.110
T3	.300	Age	.357	2.156	.038
		Gender (Female = 1)	-.490	-3.304	.002
		GPA	-.494	-3.255	.003
		Hours Game play	-.125	-.855	.398
		IVA+ Response Control	-.003	-.017	.987
		IVA+ Attention	-.169	-.954	.347
T4	.223	Age	.312	1.798	.081
		Gender (Female = 1)	-.454	-2.935	.006
		GPA	-.380	-2.433	.020
		Hours Game play	-.011	-.072	.943
		IVA+ Response Control	.086	.507	.616
		IVA+ Attention	-.219	-1.173	.249

Table 4.3 (Continued)

Electrode	Adjusted R^2	Variable	β	*t*	*p*
T6		Age	.451	2.319	.027
		Gender (Female = 1)	-.098	-.582	.565
		GPA	-.445	-2.552	.015
		Hours Game play	-.171	-1.005	.322
		IVA+ Response Control	-.064	-.331	.743
		IVA+ Attention	-.278	-1.268	.214
Cz	.296	Age	.323	1.953	.059
		Gender (Female = 1)	-.536	-3.628	.001
		GPA	-.341	-2.305	.027
		Hours Game play	-.029	-.202	.841
		IVA+ Response Control	-.091	-.556	.582
		IVA+ Attention	-.089	-.496	.623
Pz	.357	Age	.410	2.593	.014
		Gender (Female = 1)	-.503	-3.562	.001
		GPA	-.446	-3.151	.003
		Hours Game play	-.117	-.839	.407
		IVA+ Response Control	-.227	-1.444	.158
		IVA+ Attention	-.061	-.355	.725

Table 4.4

Regression Coefficients for Significant Alpha Frequency Models by Electrode

Electrode	**Adjusted R^2**	**Variable**	**β**	***t***	***p***
O1	.209	Age	.450	2.568	.015
		Gender (Female = 1)	-.293	-1.860	.072
		GPA	-.473	-2.962	.006
		Hours Game play	-.232	-1.498	.143
		IVA+ Response Control	.016	.093	.927
		IVA+ Attention	-.224	-1.195	.240
O2	.283	Age	.409	2.450	.020
		Gender (Female = 1)	-.452	-3.016	.005
		GPA	-.504	-3.313	.002
		Hours Game play	-.169	-1.147	.259
		IVA+ Response Control	-.034	-.208	.836
		IVA+ Attention	-.243	-1.363	.182

Table 4.5

Summary of Frontal Hemispheric (Electrode Pair: F3 and F4) Significant Differences in Alpha Index Scores between Game Groups

						95% Confidence Interval	
Time Interval	**Game Group**	**N**	**Mean Alpha Index**	**Mean Index Difference**	**Std. Error**	***Lower***	***Upper***
1	Violent	15	-.017	-.114	.043	-.204	-.024
	Brain Train	14	.097				
2	Violent	15	-.044	-.114	.039	-.208	-.020
	Non-Violent	15	.070				
2	Violent	15	-.044	-.133	.039	-.229	-.038
	Brain Train	14	.090				
4	Violent	15	-.042	-.095	.033	-.175	-.016
	Non-Violent	15	.053				
4	Violent	15	-.042	-.111	.033	-.192	-.030
	Brain Train	14	.069				

Table 4.6

Alpha Power Significant Main Effect of Condition from Baseline to Game Play

	Baseline	**Game Play**				
Electrode	**Mean Power Values (µV^2)**		***F***	***df***	***p***	**η^2**
FP1	9.55 (*SD*=4.45)	7.46 (*SD*=2.17)	13.62	(1,40)	.001**	.254
FP2	9.96 (*SD*=5.2)	7. 46 (*SD*=2.00)	14.55	(1,40)	.001**	.267
F3	10.96 (*SD*=5.45)	7.58 (*SD*=2.28)	24.97	(1,41)	.000**	.379
F4	12.29 (*SD*=11.83)	7.85 (*SD*=2.44)	7.13	(1,41)	.011*	.148
F7	8.80 (*SD*=4.10)	6.83 (*SD*=2.51)	16.80	(1,41)	.000**	.291
F8	9.39 (*SD*=4.80)	6.87 (*SD*=2.01)	16.99	(1,40)	.000**	.304
Fz	11.95 (*SD*=7.36)	8.33 (*SD*=2.67)	15.24	(1,41)	.000**	.271
P3	11.82 (*SD*=8.26)	6.19 (*SD*=2.77)	31.42	(1,42)	.000**	.428
P4	11.53 (*SD*=7.27)	6.75 (*SD*=2.88)	33.92	(1,42)	.000**	.444
Pz	12.88 (SD=9.79)	7.26 (SD=3.66)	26.81	(1,42)	.000**	.390
T3	7.80 (SD=5.13)	5.29 (SD=2.28)	15.87	(1,41)	.000**	.279
T4	7.95 (SD=4.60)	5.19 (SD=1.92)	25.98	(1,42)	.000**	.382

Table 4.6 (Continued)

	Baseline	**Game Play**				
Electrode	**Mean Power Values (μV²)**		***F***	***df***	***p***	**η²**
T5	8.15 (SD=6.60)	*4.76 (SD=2.35)*	*19.27*	*(1,41)*	.000**	.320
T6	8.80 (*SD*=7.83)	4.74 (*SD*=1.95)	17.96	(1,41)	.000**	.295
O1	8.00 (*SD*=4.57)	5.65 (*SD*=2.19)	21.15	(1,41)	.000**	.340
O2	8.61 (*SD*=5.13)	6.21(*SD*=2.61)	15.41	(1,41)	.000**	.273

*Indicates significance at *p*<.01
**Indicates significance at *p*<.001

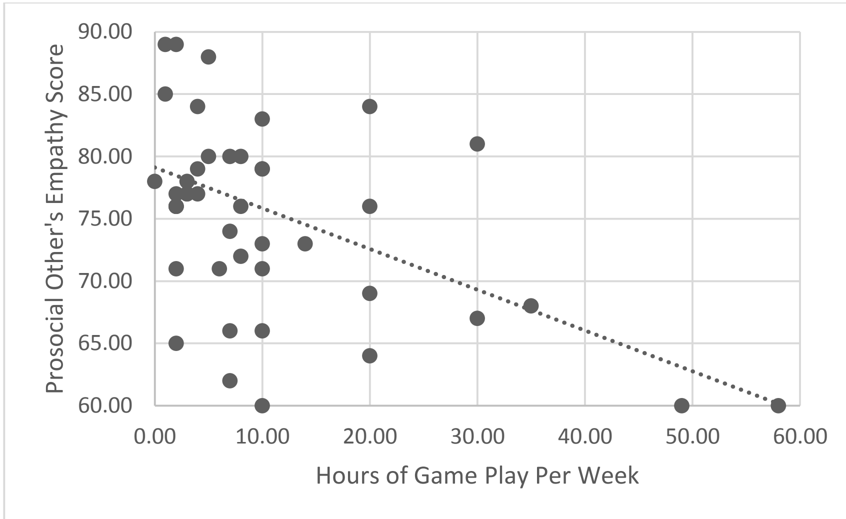

Figure 4.1. Scatterplot of hours adolescents reported playing video games per week and their corresponding score for the Others-Empathy factor on the Prosocial Personality Battery (Penner, 2010).

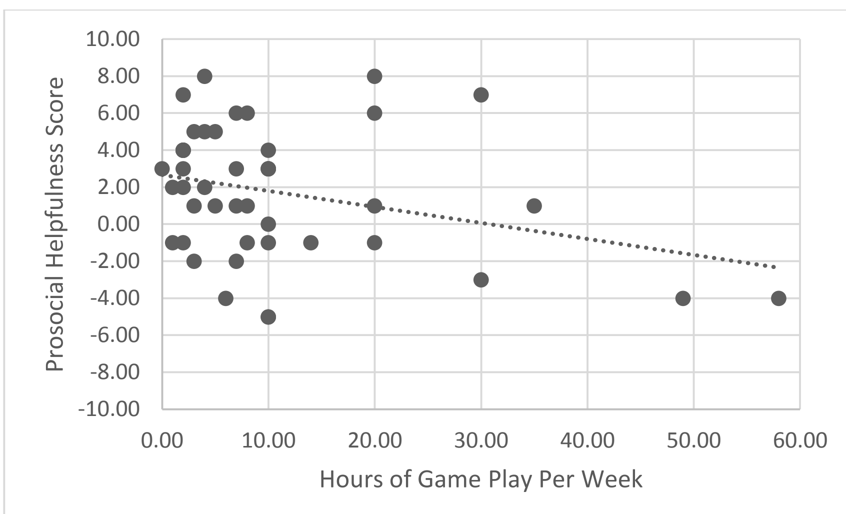

Figure 4.2. Scatterplot of adolescents reported playing video games per week and their corresponding score for the Helpfulness factor on the Prosocial Personality Battery (Penner, 2010).

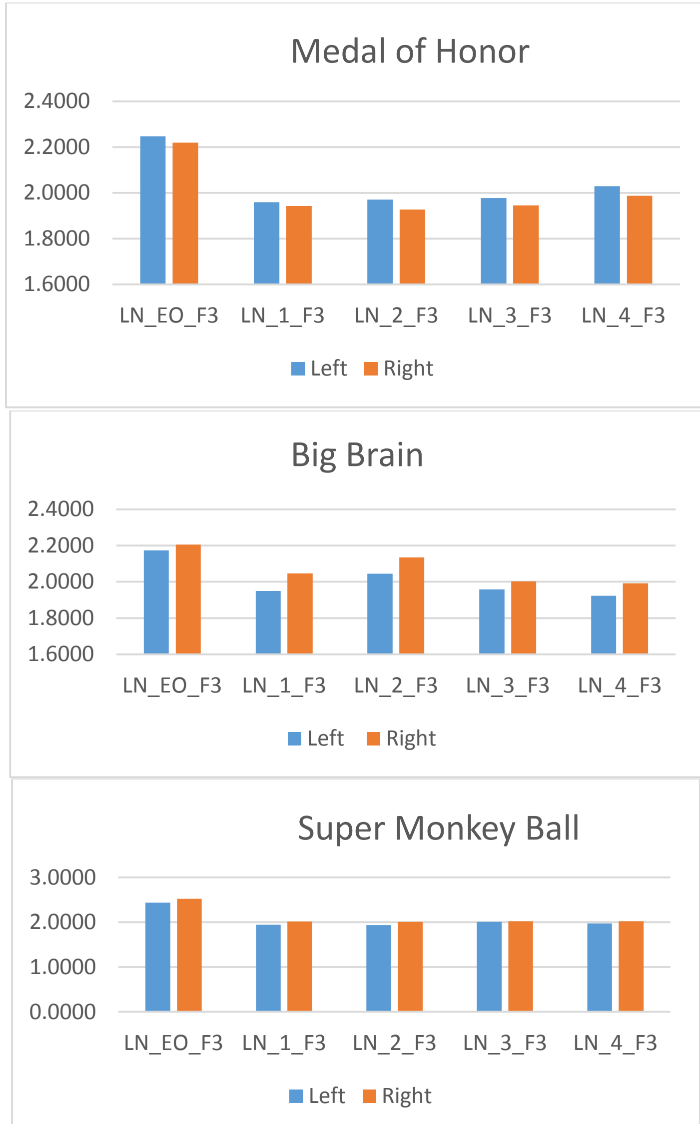

Figure 4.3. Bar graphs for natural log power values for F3 (left) and F4 (right) electrodes at no game play (LN_EO) and each 5-minute increments of 20 total minutes of game play (1-4). The graphs show decreased alpha activity in both electrodes from baseline, but left and right electrodes were reduced differently to contribute to asymmetric activity.

Chapter Five

Discussion

Participants in the present study engaged in either violent, non-violent, or non-violent brain train game play while EEG was recorded to observe electrical brain activity. In addition, measures of prosocial personality, hours spent playing video games, educational attainment, and attention was obtained. We hypothesized that prosocial personality would be negatively correlated with the number of hours participants engaged in game play per week. Our results found support for this hypothesis. The higher the hours participants reported playing video games per week, the lower their prosocial scores were on the Helpfulness and Other-Oriented Empathy subscales of the Prosocial Personality Battery. Those with lower prosocial personalities may be more drawn to self-oriented hobbies such as game play. Prosocial personality and behavior by definition focusses on the awareness of other's needs (Penner et al., 1995). If one exhibits less awareness to others than of their own self, it makes sense that video games would be an attractive hobby because it can be played solo with enough entertainment and challenges to keep an individual engaged long-term. The other possibility is that children play numerous hours of video games per week have little time to think or act in others benefit. Excessive game-playing has been found to cause rifts due to neglect in fostering relationships between family members, friends, and spouses (Coyne, et al., 2012; Chappell, Eatough, Davies, & Griffiths, 2006) so this interpretation is highly plausible.

In our second hypothesis, the relationship between grade point average and hours of video game play was investigated. No significant correlations were found between the two variables, although p-value for this analysis could be considered approaching significance. The direction of the relationship aligned with previous research on academic performance and game play (Gentile, et al., 2004; Gentile & Walsh, 2000). Given the previous research showing lower academic performance associated with video game play, we expected to find a small effect size related to hours of game play reported by the participants. Parents were present while this information was obtained and reviewed their child's reported GPA for accuracy. GPA for the most recent report card was obtained, while current weekly hours of game play reflected estimates based on present gaming habit. It is possible that number of hours reported game play was different during the semester GPA was reported. Another possibility could lie within the sample of participants itself. If parents were willing to encourage their children to participate in a research study and accompany them throughout the process, we propose that parental involvement could be factor that mediates the relationship between academic success and video game play.

As a part of investigation, our third hypothesis sought to find out if attention and hours of reported video game play were good predictors of electrical brain activation during the general video game experience. No such relationship was found as a part of the study. It is unclear why no relationship between video game play and the attention measures was not found. Perhaps the IVA+ did not encompass attentional features utilized in video game play such as attentional flexibility over time (Green & Bavelier, 2003). Another possibility could be related to how IVA+ attention scores are derived. As stated in the methods section, The *Response Control* Quotient score is comprised of impulsivity, response inhibition, and false response, while *Attention Quotient* scores are calculated from dimensions of vigilance, focus, and speed scores. Perhaps for this particular task of game playing, isolating specific aspects of attention separately would yield better predictor measures in relation to the video game experience.

Although the variables of interest, attention and time spent playing video games, were not significant, the confounding variables age, gender, and grade point average were found to be related to specific brain activity in delta, theta, and alpha frequency. This was not surprising, but it reinforced the decision to include them into the regression models. These variables were included into the regression model based on previous research discussed in the following paragraph as well as how our data coincided with existing literature.

Age is a significant factor in EEG because brain potentials vary depending on cerebral maturation starting from infancy and dematuration or decrease in brain volume occurring in middle adulthood (Sowell et al., 2006). Delta, theta, and alpha power tend to decrease along the developmental process (Matousek & Petersen, 1973; Gasser, Verleger, Bacher, & Sroka, 1988). This trend was seen in our data as well, with band power decreasing from a range of .3 to .5 microvolts with each increase in 1 year of age. Documented gender differences in EEG (e.g., Matthis et al., 1980) show females with larger amplitudes than males across the lifespan (Emmerson-Hanover, Shearer, Creel, & Dustman, 1994). This was reflected in the beta coefficients, indicating that mean power was higher in females than males in all bands and at all significant electrodes. Grade point average (GPA) was used as an indicator of general cognitive ability. Results showed that as GPA increased, mean power increased in significant models. This finding is not surprising since delta, theta, and alpha band power synchronization have been linked to attention, concentration, and mental task completion (Niedermeyer, 2005).

One of the primary interests in the current study was whether a violent video game would evoke uniquely different brain potentials than the other two non-violent games. In our fourth hypothesis, we suggested there would be group differences in occipital theta activation based on previous research (Salimen & Ravaja, 2003). No such difference was found in the present sample. Research by Lianekhammy and Werner-Wilson (2012) conducted a similar study to the present one using college aged participants. No group differences in occipital theta activation was found in that study either. Occipital theta activation in response to violent graphic material may be dependent on the level of the violence experienced.

We also posited that a left-hemispheric asymmetric activation would be greater in the violent game group compared to the non-violent groups. Much to our surprise, this was not the case. Group differences were found throughout the 20 minute game playing session, but the direction in which the differences occurred was completely opposite of what was predicted. The violent game group showed greater right hemisphere activation than the non-violent brain training game within the first 5 minutes of game play. Within 5 to 10 minutes (Time 2) and 15 to 20 minutes (Time 4) of game play, the violent game group showed greater right hemisphere activation than both non-violent game groups. The non-violent game groups consistently showed greater left hemisphere activation throughout game play, aligned with approach behavior, which could be attributed to active engagement and wanting to succeed. Salminen and Ravaja (2007) found similar left hemisphere activation in participants playing Super Monkey Ball.

Greater right hemisphere activation relates to withdrawal motivation which is defined as the avoidance of negative or undesirable event (Harmon-Jones, 2004). While it was hypothesized that the violent game group would show greater left hemisphere activation because of links to aggression and anger, the adolescent participants avoidance response to graphic content may be seen as a precursor to aggression responses that are found later on the developmental spectrum. Researchers argue that short-term aggressive behavior after violent video game play is attributed to priming existing knowledge structures (Bushman & Huesmann, 2006). As described previously in the theory section, repeated exposure to violent media can change knowledge structures in terms of aggressive beliefs, attitudes, and desensitization. Children showing right hemisphere activation in response to violent game play might reflect an appropriate response for individuals with little previous exposure to violent media content. Perhaps aggressive knowledge constructs have yet to be formed in the sample used in the study.

Based on results from previous literature, we expected to see gradual changes as exposure increases, especially with age. In an earlier study, Lianekhammy and Werner-Wilson (2012) found college aged participants exhibited a left hemisphere response when playing the same game, Medal of Honor, the adolescents played. It would stand to reason that as a function of being older and having more access to violent media without the limitations of a parent, the college-aged participants likely had more exposure to violent content than the school-aged children. Even though our hypothesis was not supported, this result associated with right hemisphere activation in adolescents is fascinating because of the juxtaposition to the college-aged participants from the earlier study. It provides a possible glimpse at how brain response could change as a result of increased violent media over time is beginning to unfold. This change can be explained in terms of desensitization theory (Funk, Bechtoldt-Baldacci, Pasold, & Baumgartner, 2004).

Desensitization theory proposes that continual exposure to violent content will result in cognitive, emotional, and physiological habituation, defined as decreased response to repeated exposure to a stimulus (Harris, 1943) to future experiences with violent content. In the case of present findings, adolescents receiving repeated exposure to violent content over time would likely express less avoidance response to graphic material.

It must be understood that the explanations for left/right hemisphere response are only speculative at this juncture. Information on previous exposure to violent media content was not collected for adolescents, nor the college-aged participants in the earlier study by Lianekhammy and Werner-Wilson (2012). To truly be able to support such speculations, a longitudinal study investigation the effects of increased violent graphic exposure over time measured by EEG would need to be conducted. To the best of our knowledge, no study exists at this present time.

Moving on to the next area of focus in the study, in the fifth research question we hypothesized that non-violent brain training games would evoke lower alpha power, associated with cognitive processing, compared to baseline than the violent and non-violent games. Results did not support this hypothesis. An overall task effect was found, showing decreased alpha power from baseline to game play. This finding reflects cortical activation and resource allocation necessary to perform mental tasks (Salminen & Ravaja, 2007) involved in video game play. An interaction was found for frontal electrode FP2, but the non-violent brain training game did not yield any significant results. The violent and non-violent games showed similar patterns of alpha desynchronization associated with game play.

In our last hypothesis, we investigated electrical brain activity over the course of 20 minutes of game play. It was posited that theta power would increase in voltage over time due to increased mental load required in game playing. There were no evidence to support this possibility. Difficulty levels for each game was set at beginners level, but games often increases in difficulty as one progresses through the challenges. It would be expected to see increased theta power as the game playing session continued, but significant frontal electrode F8 showed a decrease in voltage between game playing at 5-10 minutes and game playing at 15 to 20 minutes. This decrease in theta power could be some indication that players were beginning to become less interested in the game. Chanel et al. (2011) found that easy levels of play were related to lower arousal and lower motivation.

The presence of frontal midline theta has been found across different age groups completing mental tasks. Children aged 8-12 (Yamada, 1998) and college-students (Saliminen & Ravaja, 2007) playing video games have all exhibited frontal midline activity. As it turns out, this particular pattern of theta activity seems to disappear in adolescence (Niedermeyer, 2005) so our non-significant finding was not unusual. It has also been noted by Niedermeyer and colleagues (1989) that this pattern of brain activity is difficult to reproduce, possibly due to task specificity that has yet to be interpreted.

Limitations

The current study has several limitations worth discussing. Electrical brain activations focus on cognitive activations, thus investigating possible aggressive thought. Although the General Aggression Model posits physiological activation mediates aggressive behavior, this study does not truly address how electrical brain activations are directly linked to aggressive behavior. Another limitation of the study concerns prior exposure to video games. While participants reported the amount of hours spent playing video games per week, more contextual information about video game experience would have been helpful. Knowing how long participants had been consistently playing video games the number of hours reported and how much experience they have had previously, especially with violent content would shed more light on whether right hemispheric activation in response to violent game playing could have been associated to withdrawal behaviors due to avoidance of graphic material adolescents were not used to viewing.

It must also be noted that measures of frustration and affect were not collected as a part of the study. Although the games were set at a beginner's level, it was obvious that some players were more proficient at game playing than others. Frustration during game playing would no doubt influence physiological response recorded in the EEG's. No children expressed frustration or impatience during the study, but written measures or surveys would have corroborated these observations by the researcher. Measures assessing approach or withdrawal motivations, and aggressive cognition would have provided more clear evidence as to what was attributing to the differences in electrical brain activations between the violent and non-violent games.

Conclusion

EEG was used to assess violent, non-violent, and brain training video game play in adolescents. Some support was found for electrical activation unique to violent games that may be promising as a tool for assessing changes in response to aggression over a developmental period of time. This has several implications for therapists and practitioners working with parents who are concerned with media effects on adolescent development. The focus on violent gaming is warranted, but the overall indications from the current finding leaves room for deliberation about habituation as a mechanism underlying how one will respond to violent content in general. Limiting exposure to violent video games may be important to recommend to parents and families, but more importantly limiting violent content in general, whether it comes in the form of the nightly news, movies, etc., is more likely an effective measure to preventing repeated exposure necessary to desensitize someone to violence. Further study is needed to clarify if general adolescent population tend to show right hemispheric pattern, withdrawing from violent graphics as a defense mechanism. Longitudinal study may help identify whether brain activity changes through the developmental process, as adolescents are exposed to more violent media and becomes desensitized.

With the prevalence of video games increasing in today's society, the purpose of this study sought to identify how the brain reacts during video game play. Game content with violence, ever increasing with realistic graphics, tend to increase aggressive behavior, cognition, and emotion (Anderson, et al., 2007; Anderson et al., 2010). Video games are not without positive outcomes either. Researchers have found video games to be a powerful tool responsible for increased visual attention and reaction time (Green & Bavelier, 2003), reading comprehension (Adams, 2009), and prosocial behaviors (Gentile et al., 2009). In closing, by understanding how video games effect physiological processes researchers can make informed decisions on how to promote the use of games to for optimal benefits, rather than calling to ban the use of video games altogether.

Appendices

Appendix A

Experiential Distinctions among Three Common Video Game Genres

Demographic Questionnaire

Name: ____________________________ Participant ID#_____________

Age: __________________ Occupation: ____________________

Gender: ☐ Male ☐ Female Education/Degree:___________________

How do you define your ethnicity? (Circle all that apply)

1. **White (Caucasian)**
2. **African-American**
3. **Hispanic**
4. **Native American**
5. **Asian**
6. **Pacific Islander**
7. **Other (Please specify) _____________________**

How would you describe your total household annual income? (Circle number)

1. $0 – 9,999
2. $10,000-19,999
3. $20,000-29,999
4. $30,000-39,999
5. $40,000-49,999
6. $50,000+

How many hours a week do you play video games? _______________

What games do you most often play or prefer playing?

____

____

Appendix B

Educational Attainment Questionnaire

1. a. Please select which type of school your child currently attends:

- ☐ Public
- ☐ Non-Religious Private
- ☐ Montessori

b. Please provide the name of the school your child currently attends:

____

2. How long (in years) has your child attended this type of school? __________

3. Has your child previously attended any other types of school (i.e., public, non-religious private, religious-private, or Montessori) starting with first grade?

- ☐ Yes
- ☐ No

If you answered yes to #3, please select which of the following types of schools your child has attended before attending their current school.

- ☐ Public
- ☐ Non-Religious Private
- ☐ Religious Private
- ☐ Montessori

Please provide the name of the school(s) your child has attended:

____

If you answered yes to #3, during which grades did your child attend this type of school? (If your child attended more than one, please write the grade level associated with each type of school.)

____

4. Using the 4.0 scale, what was your child's GPA from their most recent report card?

____

Appendix C

Participant ID ____________________________

Below are a number of statements that may or may not describe you, your feelings, or your behavior. Please read each statement carefully and write in the space on your answer sheet that corresponds to choices presented below. <u>There are no right or wrong responses</u>

1 Strongly Disagree	2 Disagree	3 Uncertain	4 Agree	5 Strongly Agree

1. When people are nasty to me, I feel very little responsibility to treat them well. (R)

____

2. I would feel less bothered about leaving litter in a dirty park than in a clean one. (R)

____

3. No matter what a person has done to us, there is no excuse for taking advantage of them. __________

4. With the pressure for grades and the widespread cheating in school nowadays, the individual who cheats occasionally is not really as much at fault. (R) __________

5. It doesn't make much sense to be very concerned about how we act when we are sick and feeling miserable. (R)

____

6. If I broke a machine through mishandling, I would feel less guilty if it was already damaged before I used it. (R)

____

7. When you have a job to do, it is impossible to look out for everybody's best interest. (R) __________

8. I sometimes find it difficult to see things from the "other person's" point of view. PT (R) __________

9. When I see someone being taken advantage of, I feel kind of protective towards them. EC __________

10. I sometimes try to understand my friends better by imagining how things look from their perspective. PT

____

11. Other people's misfortunes do not usually disturb me a great deal. EC (R)

____

12. If I'm sure I'm right about something, I don't waste much time listening to other people's arguments. PT (R) __________

1 Strongly Disagree	2 Disagree	3 Uncertain	4 Agree	5 Strongly Agree

13. When I see someone being treated unfairly, I sometimes don't feel very much pity for them. EC (R)

____

14. I am usually pretty effective in dealing with emergencies. PD (R) __________

15. I am often quite touched by things that I see happen. EC __________

16. I believe that there are two sides to every question and try to look at them both. PT

____

17. I tend to lose control during emergencies. PD __________

18. When I'm upset at someone, I usually try to "put myself in their shoes" for a while. PT

____

19. When I see someone who badly needs help in an emergency, I go to pieces. PD

____

PART 2:
Below are a set of statements, which may or may not describe how you make decisions when you have to choose between two courses of action or alternatives when there is no clear right way or wrong way to act. Some examples of such situations are: being asked to lend something to a close friend who often forgets to return things; deciding whether you should keep something you have won for yourself or share it with a friend; and choosing between studying for an important exam and visiting a sick relative. Read each statement and write in the space on your answer sheet that corresponds to the choices presented below.

1 Strongly Disagree	2 Disagree	3 Uncertain	4 Agree	5 Strongly Agree

20. My decisions are usually based on my concern for other people. O __________

21. My decisions are usually based on what is the most fair and just way to act. M

____

1 Strongly Disagree	2 Disagree	3 Uncertain	4 Agree	5 Strongly Agree

22. I choose alternatives that are intended to meet everybody's needs. M __________

23. I choose a course of action that maximizes the help other people receive. O

____

24. I choose a course of action that considers the rights of all people involved. M

____

25. My decisions are usually based on concern for the welfare of others. O

____

Below are several different actions in which people sometimes engage. Read each of them and decide how frequently you have carried it out in the past. Blacken in the space on your answer sheet which best describes your past behavior. Use the scale presented below.

1 Never	2 Once	3 More than Once	4 Often	5 Very Often

26. I have helped carry a stranger's belongings (e.g., books, parcels, etc.). __________

27. I have allowed someone to go ahead of me in a line (e.g., supermarket, copying machine, etc.) __________

28. I have let a neighbor whom I didn't know too well borrow an item of some value (e.g., tools, a dish, etc.).

____

29. I have, before being asked, voluntarily looked after a neighbor's pets or children without being paid for it.

____

30. I have offered to help a handicapped or elderly stranger across a street.

____

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Educational Background:

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B.A., magna cum laude	Psychology, 1998-2002 Anthropology, 1998-2002 Western Kentucky University, Bowling Green, KY

Research Experience:

Supervisor: Ronald Werner-Wilson, Ph.D.
Chair, Department of Family Sciences, University of Kentucky
Research Assistant 2010-2012

Supervisor: Ruth Huebner, Ph.D.
Information and Quality Improvement, Department of Human Based Services
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Quality Analyst 2007-2009

Supervisor: Yang Jiang, Ph.D.
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Publications:

Lianekhammy, J. & van de Venne, J. (2014). World of Warcraft widows: Women's perspective of partners that play massively multi-Player online role-playing games excessively. *Psychology of Women Quarterly*. Manuscript submitted for publication.

Lianekhammy, J. & Werner-Wilson, R. (2014). Comparing electrical brain activity between violent and non-violent game experiences. Manuscript in preparation.

Martin, S. B., Dowling, A. L., Lianekhammy, J., Lott, I. T., Doran, E., Murphy, M. P., Beckett, T. L., Schmitt, F. A. & Head, E. (in press). Synaptophysin and synaptojanin-1 in Down syndrome with Alzheimer disease. Journal of Alzheimer's Disease.

Kimberly, C., Werner-Wilson, R. J., Parker, T., & Lianekhammy, J. (2014). Alpha to omega: Neurological analysis of marital conflict in a pilot study. *Contemporary Family Theory, 36*(1), 83-92.

Werner–Wilson, R., Lianekhammy, J., Frey, L., Parker, T., Wood, N., Kimberly, C., Perry, M., Blackburn, K., Smith, L., Terrana, K., Pucket, J., & Dalton, M. (2011). Asymmetry in female military spouses following deployment. *Journal of Feminist Family Therapy: An International Forum*, *23*(3-4), 202-217.

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Book Chapters

Werner-Wilson, R.J., Parker, T.S., & Lianekhammy, J. (in press). Mental health promotion in adolescents. In T. Gullotta and M. Bloom (Eds.), *The Encyclopedia of Primary Prevention and Health Promotion (2nd ed).*

Conference Presentations:

Lianekhammy, J. & van de Venne, J. (*proposal submitted*). *Analysis of forum messages from women with partners that play massively multi-player online role-playing games (MMORPG) excessively.* Poster presentation at National Council on Family Relations Conference, San Antonio, TX.

Lianekhammy, J., & Werner-Wilson, R. J. (2012, November). *Examination of Electrical Brain Activation in Three Different Video Game Experiences.* Poster presentation at National Council on Family Relations Conference, Orlando, FL.

Huff, N., Lianekhammy, J., & Perry, M. (2012, November). *The Impact of Well-being and Religion on Women's Relationship Satisfaction.* Paper presentation at

National Council on Family Relations Conference, Orlando, FL.

Perry, M., Huff, N., & Lianekhammy, J. (2012, September). *Women's Religiosity, Wellbeing and Relationship Satisfaction.* Poster Presentation at the American Association for Marriage and Family Therapy Conference, Charlotte, NC.

Werner-Wilson, R. J., Lianekhammy, J., Frey, L. M., Wood, N., Parker, T., Kimberly, C., Perry, M., Blackburn, K., Smith, L., Terrana, K., Dalton, M., & Puckett, J. (2011, November). A Pilot Study Comparing Influence of Deployment on Military Families. National Council on Family Relations, Orlando, FL.

Huebner, R. A., Lianekhammy, J., & Brock, A., (2008, July). *Making provider-collected and administrative data work together for program evaluation*. Presentation at the 11th National Child Welfare Data and Technology Conference, Washington, D.C.

Davis, L., Daughtery, R., & Lianekhammy, J. (2007, June). *First steps and critical components of engaging birth parents.* Presentation at Family to Family Southeast Regional Convening 2007, Rewriting Child Welfare's Future: Engaging Birth Parents and Foster Youth in System and Self-Advocacy Work, Louisville, KY.

Manson, D. A., Lianekhammy, J., & Ard, C. (2007, May). *Racial disproportionality: Addressing the gaps with Citizen Review Panels.* Presentation at the Sixth Annual Citizen Review Panel National Conference, Lexington, KY.

Vagnini, V.L., Lawson, A.L., Liu, X., Lianekhammy, J., Bylica, K.E., Joseph, J., Kelly, T.H., &
Jiang, Y. (2005, June). *The effect of sensation seeking on a novelty detection task: An ERP study.* Poster presented at the National Institute on Drug Abuse Satellite Meeting entitled: Translating Basic Research From Neural, Behavioral, & Social Sciences to Prevention: Challenges & Opportunities, Orlando, FL.

Norman, J. F., Norman, H.F., Lianekhammy, J., Clayton, A. M., & Zielke, G. (2003, May). *The visual and haptic perception of natural object shape*. Poster presentation at the 2003 annual meeting of the Vision Sciences Society, Sarasota, FL.

TEACHING EXPERIENCE:

2012	Instructed FAM 390: Introduction to Research in Family Sciences Supervised by Dr. Donna Smith, Family Sciences Associate Professor
2008-2009	Guest Lecturer for Dr. Diana Haleman, Family Sciences Lecturer: FAM 354: Intro to Cross-Cultural Perspectives Topic: Asian American Families

FAM 544: Cultural Diversity in American Children and Families
Topic: Child Welfare System

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Certifications:

2012 Graduate Certificate in Applied Statistics

Awards:

2103 National Council on Family Relations Outstanding Graduate Student Paper Award

2011 University of Kentucky Family Sciences Graduate Student Excellence Award

2007 Certificate of Excellence from the Commissioner of the Department for Community Based Services: for outstanding work in data analysis, program presentation and dedication to vulnerable children and families

Funding:

2014 Alice P. Killpatrick Fellowship
- $2,500 financial award

2009- 2012 Lyman T. Johnson Academic Fellowship
- $15,000 max assistantship including tuition and health insurance

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2011- 2013 Graduate Representative on Family Sciences Department Curriculum Committee

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2012 Volunteer reviewer for National Conference on Family and Relations

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Community Service:

2006-2013	Volunteer	Sayre Christian Village Assisted Living Facility Lexington, KY 40517
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