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Links to Prosocial Factors and Alpha Asymmetry in Adolescents during Violent and Non-Violent Video Game Play

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The present study examined electrical brain activations in participants playing three different video games. Forty-five adolescents between the ages of 13-17 (*M*=14.3 years, *SD*=1.5) were randomly assigned to play either a violent game, non-violent game, or brain training game. Electroencephalography (EEG) was recorded during video game play. Following game play, participants completed a questionnaire measuring prosocial personality. Results show an association between prosocial personality factors and differential patterns of brain activation in game groups. Adolescents with higher empathy playing the brain training game were positively correlated with frontal asymmetry scores, while empathy scores for those in non-violent and violent game groups were negatively linked to frontal asymmetric activation scores. Those with higher scores in helpfulness in the non-violent game group showed a positive association to left hemisphere activation. Implications behind these findings are discussed in the manuscript.

Keywords: prosocial, empathy, helpfulness, violent video game, non-violent video game

According to a report by Newzoo, a global game market research company, there were 1,231 million people who played video games worldwide in 2013 (Global Games Market Report). Given the popularity and prevalence of video games, social scientists have put forth great effort into understanding the potential effects of this type of media entertainment. With game players 17 or younger representing 29% of all those who play (ESA, 2014) video games, the effects are of particular concern for adolescents 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).

Negative Outcomes of Video Games

The effects of violent video game content and aggression has been a primary focus of investigators, due to concerns that gratuitous violence and the interactive nature of gaming may lead to increased negative outcomes outside of the game environment (Anderson et al, 2010). Meta-analytic findings show mixed results concerning the effects of playing games with violent content. Some find results indicating strong evidence that violent video game exposure is associated with increased aggressive affect, behavior, cognition, and physiological measures, (Anderson & Bushman, 2001; Anderson, 2004; Anderson et al., 2010). Others show the effect of video game violence on aggression is minimal to non-existent (Ferguson

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et al., 2008; Ferguson, 2008). Support for this claim is strengthened by findings from longitudinal (Williams & Skoric, 2005) and other published meta-analytic studies that show little to no relationship between violent video game play and aggression (Ferguson, 2007; Savage & Yancey, 2008; Ferguson & Kilburn, 2010).

More recently, video game literature has further investigated the effects of video game content on prosocial behavior, behavior defined broadly as acting in a way that benefits others (Penner, Dovidio, Pilavin, & Schroaeder, 2005). Evidence for decreased prosocial behavior after violent video game play has been reported through meta-analytic reviews of studies using samples of children and adults (Anderson & Bushman, 2001; Anderson, et al., 2010), across different cultures (Gentile, et al., 2009; Prot, et al., 2013). Children engaging in violent video game play show decreased prosocial behaviors such as helpful behavior (Saleem, Anderson, & Gentile, 2012) as well as decreased prosocial affect such as empathy (Funk, Buchman, Jenks & Bechtoldt, 2003).

Methodological Concerns

There are several methodological issues found in the video game body of literature, which may account for discrepant findings primarily in the body of literature concerning video games and negative outcomes. In a meta-analysis conducted by Anderson (2004), methodological problems were identified within the sample reviewed. First, some studies using non-violent video game conditions used games that contained mild violence. Other studies investigated effects of violent video game play, but failed to use non-violent control condition for comparison. The current study uses two different non-violent games as a control condition to the violent game condition. One of the control games may be considered to contain very mild instances of violence (e.g., character dying), while the other non-violent game (i.e., braining training) contains no instances of violence. The differences between the two types of non-violent games will be compared in the current study to understand the influences of mild violence in games considered to be non-violent.

Sample size is often cited as a methodological issue of video game research. In a review of 12 different studies, Gentile and Stone (2005) found that many of the sample sizes used in video game studies were not large enough to detect an effect. On average, video game studies had sample sizes of about 20, but Gentile and Stone (2005) noted that sample sizes of 200 are required for sufficient power. While the suggested sample size for behavioral research is 200 for, sample size sufficient in research utilizing EEG methodology tends to be much smaller, ranging from 15-40 participants (Robinson, 2007). Additional research using different methods of investigation is needed to clarify findings in the video game body of literature, particularly addressing the discrepant studies regarding the relationship between violent video games and negative effects.

Positive Video Game Outcomes

While video game research has been heavily focused on the negative effects of video games, it is important to emphasize that research has also found positive effects resulting from game play. Video games containing prosocial content produce opposing outcomes compared to games with violent content (Sestir & Bartholow, 2010). Prosocial game play increases empathy and helping behaviors consistently among different cultures and age groups (Gentile, et al., 2009; Prot, et al., 2013; Saleem, Anderson, & Gentile, 2012). Research by Sestir and Bartholow (2010) show that non-violent video games with no prosocial content may also result in increased prosocial-related outcomes if game play involves logic and problem-solving. Violent game effects are thought to occur due to the increased accessibility of aggressive constructs in memory from repeated exposure (Anderson & Bushman, 2002). If violent video games prime aggressive-related constructs, Sestir and Bartholow (2010) posit that repeated exposure to non-violent games could have the opposite effect in reducing aggression. The researchers suggested that non-violent games requiring higher cognitive executive functions, such as logic and reasoning, could possibly decrease aggression and increase the accessibility of prosocial cognitions by inducing "a more reasoned, less impulsive mind-set in players… (Sestir & Bartholow, 2010, p. 941)."

Social Neuroscience

Previous work concerning prosocial constructs such as behavior and affect have largely used behavioral methodology, but the advancement in social neuroscience has provided researchers with new methodologies to investigate the underlying physiological mechanisms of video game effects (Carnagey, Anderson, & Bartholow, 2007). Social neuroscience utilizes 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 generally 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.

The aim of the present study was to further investigate video game content and the influence of prosocial constructs in relation to electrical brain activity during video game play using quantitative electroencephalography. Quantitative EEG describes a method of quantifying recorded activity using algorithms to understand the spectral content of the brain's electrical signals (Kaiser, 2006). Physiological measures can be a powerful research tool that provides supplemental information about psychological occurrences such as attention, emotion, or arousal (Ravaja, 2004). In some cases, physiological measures can be more advantageous compared to self-report questionnaires in that physiological components measured are less influenced by external response bias (e.g., being politically correct or responding according to social norms) and provides insight to emotional responses that the participants may not be aware of experiencing (Ravaja, 2004).

EEG is a widely researched technique used to measure electrical brain activity associated with various 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). 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. Frequencies used commonly in research include: *delta* (0.5 to 4 Hz), *theta* (4 to 8 Hz), *alpha* (8 to 13 Hz), and *beta* (> 13 Hz) (Teplan, 2002).

The current study particularly focused on the alpha band, the most dominant frequency among normal adults in a relaxed state of wakefulness (Teplan, 2002; Davidson et al., 2000). For social and personality research, incongruent alpha band activation between the left and right hemispheres of the brain reveal patterns related to motivational direction (Rybak, Crayton, Young, Herba, & Konopka, 2006; Gable & Harmon-Jones, 2008). 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). 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, 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 (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).

Several studies have shown evidence supporting the relationship between prosocial measures and differential hemispheric activation (Tullet, Harmon-Jones, & Inzlicht, 2012; Paulus, Kuhn-Popp, Licata, Sordian, & Meinhardt, 2013; Hawks et al., 2015). Tullet, Harmon-Jones, and Inzlicht (2012) found a link between empathy and right hemisphere activation, mediated by sadness in college students. Researchers suggest that empathic concern may be an unpleasant emotional state, which would therefore evoke neural activity related to withdrawal motivation. Paulus et al. (2013) found greater left hemisphere activation was positively correlated with infants' greater recognition of other's distress, while greater right hemisphere activation was related to instrumental helping. In adolescents, Hawks and colleagues (2015) showed left hemispheric asymmetric activation in adolescents was positively correlated with expressions of empathy. These studies suggest that context in empathy may be important in determining the direction of asymmetric brain activation in all age groups.

The literature concerning video game play and its influence on brain activity using power estimates (μV^2) from quantitative EEG measures are limited, but previous research has shown it is a sensitive, reliable physiological measure for capturing brain activation related to video game play (e.g.,Yamada, 1998; Salminen & Ravaja, 2007; 2008). Yamada (1998) examined brain wave activation in 10 school-aged children completing a video game (*Super Mario Brothers 3*), mental test, and animation. Results indicated that brain activation was most pronounced during video game play and similar to patterns found in tasks demanding concentration. In 2007, Salminen and Ravaja found distinct differential EEG responses in college-aged students playing Super Monkey Ball 2. When players fell off the raised game board, EEG activity evoked a greater left compared to right hemispheric response possibly indicative of an approach-oriented emotion. Activation related to relaxation and motor function was also found. Following that investigation, Salminen and Ravja (2008), examined EEG responses when young adults played a first person perspective game that required them to kill in-game opponents. 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, which the researchers suggest could be indicative of increased concentration and processing emotional information.

To the best of our knowledge, no study has yet examined the link between prosocial constructs and alpha asymmetric brain activation evoked during violent and non-violent video game play in adolescents. The relationship between prosocial personality and adolescent brain activity during violent and non-violent video game play was examined. Given the previous findings concerning prosocial behavior and alpha asymmetric activation (Hawks et al., 2015; Paulus et al., 2013; Tullet, Harmon-Jones, & Inzlicht, 2012), we predicted that adolescents with greater prosocial personality scores would show differential hemispheric brain responses in relation to violent and non-violent video games.

Method

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 recruit children with interest in participating in the study. This was emphasized to the parent/guardian to prevent parental pressure or coercion. Forty-five adolescents (See Table 1 for demographic information) 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) was 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 $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*. The standard controller or Wii Remote features motion sensing capability which allows users to interact with the screen through gesture recognition. Participants playing *Medal of Honor* used the Wii Zapper, an accessory which allows the standard controller to be converted into a gun. Participants did not display any signs of difficulty adapting to the use of either controller for game play. 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

Table 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)
Other-Oriented Empathy Prosocial Score	77.13 (SD=7.5)	75.80 (SD=7.1)	73.87 (SD=10.6)
Helpfulness Prosocial Score	23.3 (SD=5.1)	22.9 (SD=4.3)	24.7 (SD=4.2)

*p<.05.

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 Ravaja'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, sex, 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.

Measure of Prosocial Personality. Participants completed the Prosocial Personality Battery (Penner, 2002) after video game play. The Prosocial Personality Battery (Penner, Fritzsche, Craiger, & Freifeld, 1995) comprises 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 & 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 were 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 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. A research assistant explained the IRB with the participants to make sure all parts were clear. Participants were reminded that they could discontinue participation at any time. Next, a self-report questionnaire collecting demographic information was filled out.

Once the questionnaire was completed, a research assistant attached an electrode cap and sensors to the participant's wrists/arms that measured physical and mental arousal. Once the electrode cap and sensors were 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 were randomly assigned to play 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 to 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 (Penner, 2002).

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. DC offset voltage was used to determine quality of connection between the electrode and scalp. Voltages less than 25,000 μV are typical of good connections (Sullivan, Deiss, Cauwenberghs, & Jung, 2007). All electrode offset values were at or below 25,000 μV at the start of recording. Frontal electrodes (i.e., FP1, FP2, F3, F4, F7, F8,) were used in data analysis. Fast Fourier transform (FFT) was use to derive artifact-free power estimates (μV2) for the alpha frequency band.

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). At least 30 seconds of clean EEG epochs were used for the analyses.

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, it 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). An alpha asymmetry index was computed for frontal electrode pairs (i.e, FP2/FP1, F4/F3, and F8/F7) for each individual in the study to examine hemispheric differences. The frontal alpha asymmetry indexes were segmented into four time periods during video game play: Time 1 (5 minutes), Time 2 (5-10 minutes), Time 3 (10-15 minutes), and Time 4 (15-20 minutes).

Statistical Analyses

Basic demographic information were analyzed to compare and contrast each of the game groups (i.e., violent, non-violent, and brain train). Continuous variables age and hours of reported video game play were analyzed using a one-way analysis of variance (ANOVA). Chi-squared tests of independence were used to analyze nominal variables gender and race.

Pearson correlation was used to analyze the relationship between the two prosocial personality factors (Other-Oriented Empathy and Helpfulness) and alpha asymmetry indexes for each of the three gaming groups at all four time periods. Two participants completed the Prosocial Personality Battery questionnaire, but each failed to answer one of the 30 questions. Rather than exclude the participant, the average response of the sub-scale skipped was used in place of the missing data. To account for multiple testing issues and non-normality of some of the variables, parameter estimates were obtained using bootstrap analysis (Westfall & Young, 1993) with 1,000 samples, using bias corrected and accelerated confidence intervals. Correlations are considered significant if the 95% confidence intervals for the parameter estimate do not contain zero. All variables met the statistical assumptions of the test required for validity.

Group differences in prosocial factors and brain activation were assessed. A one-way ANOVA was used to investigate group differences (violent, non-violent, brain train) in Other-Oriented Empathy and Helpfulness. To investigate whether brain activation changed over the course of video game play, 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, which is rarely met with psychophysiological data (Vasey & 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 alpha asymmetry index scores. Post-hoc analyses were conducted for all significant findings using Tukey's test.

Results

Descriptive Statistics

A main effect of hours of 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 the 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 (49 and 58 hours), inflating the group's mean. No group differences were found for age ($p = .812$). A chi-squared test of independence was conducted looking at gender and race between groups and no significant differences were found ($p > .05$). Table 1 provides a breakdown of each variable with group averages and percentages.

Bi-variate Relationships

Two participants with outlying values were excluded from the dataset to determine if group differences in hours of reported game play per

Table 2

Pearson Correlations between Other-Oriented Empathy, Helpfulness, and Alpha Asymmetry Index Scores for during Wii Degree: Big Brain Academy (n=13).

Electrode Pairs FP1/FP2

Measure	1	2	3	4	5	6
1. Other-Oriented Empathy	-					
2. Helpfulness	.196	-				
3. Alpha Asymmetry at Game Play–Time 1	-.348	.028	-			
4. Alpha Asymmetry at Game Play–Time 2	-.306	-.037	.777*	-		
5. Alpha Asymmetry at Game Play–Time 3	-.531	.225	.794*	.742*	-	
6. Alpha Asymmetry at Game Play–Time 4	-.508	.247	.660*	0.607	.862*	-

Electrode Pairs F3/F4 BBA

Measure	1	2	3	4	5	6
1. Other-Oriented Empathy	-					
2. Helpfulness	.135	-				
3. Alpha Asymmetry at Game Play–Time 1	-.402	-.241	-			
4. Alpha Asymmetry at Game Play–Time 2	.064	-.378	.704*	-		
5. Alpha Asymmetry at Game Play–Time 3	.217	-.319	.480	.700*	-	
6. Alpha Asymmetry at Game Play–Time 4	.552*	-.286	.206	.367	.599	-

Electrode Pairs F7/F8

Measure	1	2	3	4	5	6
1. Other-Oriented Empathy	-					
2. Helpfulness	.114	-				
3. Alpha Asymmetry at Game Play–Time 1	-.020	-.259	-			
4. Alpha Asymmetry at Game Play–Time 2	.546	.045	.512	-		
5. Alpha Asymmetry at Game Play–Time 3	.591*	-.232	.565*	.666*	-	
6. Alpha Asymmetry at Game Play–Time 4	.669*	-.152	.495	.676*	.812*	-

*Denotes significance. Confidence intervals do not intersect with zero.

week would still remain. After excluding these two participants, results of the one-way ANOVA analysis showed that while violent game group average of hours of reported game play (*M*=12.23, *SD*=10.1) was higher than the brain training group (*M*=5.13, *SD*=4.9) and non-violent group (*M*=9.3, *SD*=8.4), these group differences were not significant (*F*(2)40=2.806, *p*=.702). This finding led to the decision to exclude the two participants from the Pearson correlation analyses to prevent confounding. Variation in sample size in these analyses may also reflect loss of data due to EEG artifact, rendering the recording at a specific site unusable. Pearson correlation coefficients were obtained for variables of interest.

Results of the bivariate correlations showed a relationship between the prosocial and alpha asymmetry indexes for participants who played *Wi Degree Big Brain Academy* (See Table 2).

Table 3

Pearson Correlations between Other-Oriented Empathy, Helpfulness, and Alpha Asymmetry Index Scores for during Medal of Honor Game Play (n=13).

Electrode Pairs FP1/FP2

Measure	1	2	3	4	5	6
1. Other-Oriented Empathy	-					
2. Helpfulness	.056	-				
3. Alpha Asymmetry at Game Play–Time 1	-.205	.197	-			
4. Alpha Asymmetry at Game Play–Time 2	-.322	.172	.600	-		
5. Alpha Asymmetry at Game Play–Time 3	.166	.461	.584*	.229	-	
6. Alpha Asymmetry at Game Play–Time 4	-.157	.226	.323	-.261	.522	-

Electrode Pairs F3/F4

Measure	1	2	3	4	5	6
1. Other-Oriented Empathy	-					
2. Helpfulness	.056	-				
3. Alpha Asymmetry at Game Play–Time 1	-.514	.002	-			
4. Alpha Asymmetry at Game Play–Time 2	-.526*	.093	.528	-		
5. Alpha Asymmetry at Game Play–Time 3	-.073	.088	.725*	.382	-	
6. Alpha Asymmetry at Game Play–Time 4	-.578*	-.006	.668*	.231	.524	-

Electrode Pairs F7/F8

Measure	1	2	3	4	5	6
1. Other-Oriented Empathy	-					
2. Helpfulness	.046	-				
3. Alpha Asymmetry at Game Play–Time 1	-.393	-.171	-			
4. Alpha Asymmetry at Game Play–Time 2	-.653*	-.206	.732*	-		
5. Alpha Asymmetry at Game Play–Time 3	-.084	-.059	.869*	.526	-	
6. lpha Asymmetry at Game Play–Time 4	-.336	-.096	0.691	0.710	0.684	-

*Denotes significance. Confidence intervals do not intersect with zero.

For *Wii-Degree: Big Brain Academy* (*n*=13), F3/F4 at Time 4, 95% CI[.026, .854] and F7/F8 asymmetry scores Time 3, 95% CI[.103, .888] and Time 4, 95% CI[.129, .906] were positively correlated with Other-Oriented Empathy. Alpha frequency band activity is inversely related to cortical activity (Harmon-Jones & Peterson, 2009) so positive Pearson's r values indicate greater left hemisphere activity in participants playing *Wii Degree*. These relationships between Other-Oriented Empathy and alpha asymmetry index scores were moderate to strong in magnitude. For the other prosocial factor, Helpfulness, there were no significant findings.

Alpha asymmetry index scores were positively correlated with one another at different time points of brain training game play. At FP1/FP2 scores at Time 1 was strongly correlated with scores at Time 2, 95% CI[.462, .938]; Time 3, 95% CI[.400, .987]; and

Table 4
Pearson Correlations between Other-Oriented Empathy, Helpfulness, and Alpha Asymmetry Index Scores for during Super Monkey Ball (n=15).

Electrode Pairs FP1/FP2

Measure	1	2	3	4	5	6
1. Other-Oriented Empathy	-					
2. Helpfulness	.425	-				
3. Alpha Asymmetry at Game Play–Time 1	.091	.021	-			
4. Alpha Asymmetry at Game Play–Time 2	.076	-.194	.864*	-		
5. Alpha Asymmetry at Game Play–Time 3	.025	-.092	.859*	.854*	-	
6. lpha Asymmetry at Game Play–Time 4	.403	-.237	0.534	.646*	.565*	-

Electrode Pairs F3/F4 BBA

Measure	1	2	3	4	5	6
1. Other-Oriented Empathy	-					
2. Helpfulness	.425	-				
3. Alpha Asymmetry at Game Play–Time 1	.008	.217	-			
4. Alpha Asymmetry at Game Play–Time 2	.010	.322	.880*	-		
5. Alpha Asymmetry at Game Play–Time 3	.054	.553*	.744*	.808*	-	
6. pha Asymmetry at Game Play–Time 4	.231	.531*	.502	.503	0.568	-

Electrode Pairs F7/F8

Measure	1	2	3	4	5	6
1. Other-Oriented Empathy	-					
2. Helpfulness	.425	-				
3. Alpha Asymmetry at Game Play–Time 1	-.373	.195	-			
4. Alpha Asymmetry at Game Play–Time 2	-.455*	.048	.877*	-		
5. Alpha Asymmetry at Game Play–Time 3	-.395*	.314	.793*	.791*	-	
6. pha Asymmetry at Game Play–Time 4	-.205	.119	.641*	.762**	.635*	-

*Denotes significance. Confidence intervals do not intersect with zero.

Time 4, 95% CI[.184,.976]. Asymmetry scores at Time 2 and Time 3, 95% CI[.256, .960]; as well as Time 3 and Time 4, 95% CI[.119, .993] were significantly correlated. At F3/F4, asymmetry scores were significant at Time 1 and Time 2, 95% CI[.335, .892]; and Time 2 and 3, 95% CI[.224, .924]. At F7/F8, asymmetry scores were significant for Time 1 and Time 3, 95% CI[.119, .826]; Time 2 and Time 3, 95% CI[.111, .900]; and Time 3 and Time 4, 95% CI[.417, .966].

In an investigation of participants playing *Medal of Honor*, bivariate correlations revealed significant negative correlations between Other-Oriented Empathy and index scores for electrode pair F3/F4 at Time 2, 95% CI[-.813, -.167]; and at Time 4, 95% CI[-.880, .-.083] (See Table 3). Other-Oriented Empathy was also associated with the index score for F7 and F8 at Time 2, 95% CI[.-.924, -.205]. As mentioned in the previous paragraph, alpha is inversely related to cortical activity so negative correlations indicate greater right over left hemisphere activity. No associations between Helpfulness and frontal alpha asymmetry index scores were found for those playing *Medal of Honor*.

Alpha asymmetry index scores were positively correlated with one another at different time points of violent game play. At FP1/FP2, asymmetry scores were significantly correlated between Time 1 and Time 3, 95% CI[.244, .899]. At F3/F4, asymmetry scores were significantly correlated between Time 1 and Time 3, 95% CI[.264, .944]; and Time 1 and Time 4, 95% CI[.205, .938]. At F7/F8, asymmetry scores were significantly correlated between Time 1 and Time 2, 95% CI[.107, .935]; and Time 1 and Time 3, 95% CI[.514, .982].

For Super Monkey Ball, Other-Oriented Empathy was significantly correlated with F7/F8 asymmetry scores at Time 2, 95% CI[-.719, -.191]; and Time 3, 95% CI[-.606, -.183]. An association between Helpfulness was found with F3/F4 asymmetry scores at Time 3, 95% CI[.009, .834]; and Time 4, 95% CI[.155, .866] (See Table 4). Asymmetry scores were significantly correlated with one another at FP1/FP2 between Time 1 and Time 2, 95% CI[.485, .979]; Time 1 and Time 3, 95% CI[.550, .956]; Time 2 and Time 3, 95% CI[.461, .970]; Time 2 and Time 4, 95% CI[.124, .953] and Time 3 and Time 4, 95% CI[.072, .903]. At F3/F4, asymmetry scores were significantly correlated with one another at Time 1 and Time 2, 95% CI[.675, .970]; Time 1 and Time 3, 95% CI[.415, .892]; and Time 2 and Time 3, 95% CI[.540, .934]. At F7/F8, asymmetry scores were significantly correlated during Time 1 and Time 2, 95% CI[.675, .979]; Time 1 and 3, 95% CI[.527, .971]; Time 1 and Time 4, 95% CI[.296, .915]; Time 2 and Time 3, 95% CI[.517, .941]; Time 2 and 4, 95% CI[.487, .929]; and Time 3 and Time 4, 95% CI[.199, .945].

Game Group Differences

Results of the one-way ANOVA showed no statistical difference between groups for Other-Oriented Empathy ($F(2,42)=.552$, $p=.580$) and Helpfulness ($F(2,42)=.503$, $p=.503$). Group means for each prosocial factor are included with the descriptive statistics in Table 1.

Asymmetric hemisphere activation was also studied comparing alpha asymmetry index scores between groups with a MANOVA f or electrode pairs: FP1/FP2, F3/F4, and F7/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 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, ($F(2, 41) = 1.96$), $p<.05$). 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

Table 5
Summary of Significant Differences in F3/F4 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				

game play (*F*(2,41)=6.82, *p*<.01, ɳ2=.250), and Time 4 which captures play time 15-20 minutes into the game (*F*(2,41)=6.68, *p*<.01, ɳ2=.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 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/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).

Discussion

Our hypothesis predicted adolescents with higher empathy and helpfulness traits would show differential patterns of hemispheric brain activity in response to video game content. This hypothesis was supported. Results revealed a negative link between empathy scores and right hemisphere asymmetric activity in the violent video game and non-violent game. As empathy scores increased, adolescents playing the violent game (*Medal of Honor*) and the non-violent game (*Super Monkey Ball*) showed greater right brain activation which is also related to withdrawal motivation (Harmon-Jones, 2003). Since the violent video game used in the study required players to shoot and kill enemy opponents, the appearance of greater right asymmetric activation which is also linked to the avoidance of negative or undesirable events is compatible for individuals with greater empathy. Adolescents with higher empathy scores would likely be more able to feel responsible and concerned about the welfare of others than those with lower scores (Penners, Fritzsche, Craiger, & Frieifeld, 1995). However, this interpretation is muddied by results showing adolescents with higher empathy scores playing the non-violent game was also related to greater right hemisphere activation. The non-violent game contained mild instances of violence such that players watched their characters die if they failed to keep it positioned on the raised game board. This finding is particularly interesting given that those playing the brain training game had an opposite pattern in brain response. Further research is needed to determine if instances like repeatedly viewing the death of a game character plays a role in eliciting similar patterns of brain activation between those playing violent and non-violent games.

Adolescents playing the non-violent game also showed greater left activation in relation to higher helpfulness scores. Salminen and Ravaja's study (2007) also found frontal left hemisphere activation in response to the falling event during a similar Super Monkey Ball game. Researchers suggest that this finding my represent a positive challenge in the wake of clear failure. The goal of the non-violent game was to move a character through a raised maze without falling off. Greater left hemisphere activation may be linked to players' desire to safely maneuver their character to the end of the maze. It is likely that helpful individuals would exhibit brain activation related to approach motivation, in order to have the drive to assist others. It is important to note that this pattern of brain activity was different than Paulus et al.'s (2013) findings which showed instrumental helping was related to greater right activation in infants. More research is needed to understand if developmental differences in infants and adolescents exist in the relationship between asymmetric activation and prosocial measures of helpfulness.

In the brain training game, *Wii Degree: Big Brain Academy*, adolescents with greater empathy and helpfulness scores showed a positive relationship with frontal asymmetric activation, indicating greater frontal left hemisphere activity that is often related to approach motivation. Adolescents with greater empathy and helpfulness scores playing the brain training game may be exhibiting brain activity linked to greater approach motivation to succeed in performance situations that present mastery of goals and achievement (Elliot & Church, 1997). The cognitive tasks required by the brain training game could have resulted in higher left hemisphere activation in those with greater prosocial scores, which also supports Sestir and Bartholow's (2010) finding that games containing puzzle solving or logical components are able to enhance the accessibility of prosocial constructs.

Many of the alpha asymmetry scores were correlated with one another at different time points among the different frontal electrodes. This was expected since participants were engaged in the same type of game play throughout all four time segments.

In exploring the group effects in prosocial scores and alpha asymmetry scores, we found no group differences in empathy or helpfulness scores. There were differences found in electrical brain patterns between groups. The violent game group showed greater right hemisphere activation than the non-violent brain training game within the first 5 minutes of game play (Time 1). Within 5 to 10 minutes (Time 2) and 15 to 20 minutes (Time 4) of game play. The non-violent game and brain training game groups consistently showed greater left hemisphere activation throughout game play, which could be attributed to active engagement and wanting to succeed. Mediational analyses may be required to understand why the non-violent game showed a greater right hemisphere association in those with greater empathy scores, while greater left hemisphere activation was present in the overall group.

Limitations

The current study has several limitations worth discussing. Although participants reported the amount of hours spent playing video games per week, more contextual information about video game experience would have been helpful, such as knowing how long participants had been consistently playing video games the number of hours reported and how much experience they have had previously. 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 arousal and physiological response recorded in the EEG's. No children expressed outward frustration or impatience during the study, but written measures or surveys would have corroborated these observations by the researcher. The difference in motor skills required in each game could have also contributed to varying brain activity. However, motor processes are usually detected in higher frequency bands such beta (16-20 Hz). A previous video game study by Salminen and Ravaja (2008) found central low alpha asymmetry over motor areas of the brain, but the current study focused primarily on frontal electrodes.

Player perspective during game play was also a limiting factor in this study. The violent game was in first person, while players controlled characters in both non-violent games. This may be one reason why those with higher levels of helpfulness who played the violent video game showed no association to asymmetric brain activity. It is possible that adolescents playing the non-violent game viewed their characters separate from themselves because of the third person perspective and their characters needed help. Those playing the shooter game may have perceived their character as an extension of themselves because of the first person perspective.

Those with greater empathy scores in the violent and non-violent game conditions showed relationship related to greater right hemisphere activation. It is unclear whether asymmetric activation reflected avoidant behavior due to game content or if participants enjoyed playing the game. However, research has found greater left frontal activity is related to positive emotions and negative emotions are related to greater right activation (Tomarken, Davison, Wheeler, & Doss, 1992). If participants enjoyed playing the violent and non-violent games, we would expect to see greater left hemisphere activation, but this was not the case. Collecting measures assessing approach or withdrawal motivations, as well as measures of affect would have provided more clear evidence to better understand if differences exist in electrical brain activations between the violent and non-violent games in relation to prosocial factors.

During methodological procedures, the prosocial personality measure was taken after game play. It is possible that the violent content affected the participant's emotional state while completing the assessment. If game content did influence participant responses, this could provide support for the relationship between emotions evoked during video game play and different patterns of brain activity. However, we acknowledge that the study design should have systematically controlled and measured the magnitude of possible effects by counterbalancing the timing in which the prosocial personality assessment was taken.

Future Directions

Further study is needed to clarify whether adolescents with greater empathy show right hemispheric pattern when viewing violent content as a result of withdrawing from violent or unpleasant content or if this pattern of activation is due to some other underlying mechanism. Future studies should also aim to identify the relationship between helpfulness and brain activity specifically in adolescents and determine if this pattern changes over the developmental period.

Adolescent participants appear to exhibit brain patterns related to avoidant response to different types of video game content in violent and non-violent games containing mild forms of violence. In retrospect, it is important for future research to focus on the effects of specific gaming events rather than capture a timespan representative of the overall gaming experience. Time-locked video recording through technology such as vertical interval time code (VITC) can help researchers delineate between wide ranges of various emotions evoked during game play.

Conclusion

While the current study is not without limitations, it was an initial attempt to assess the relationship between prosocial factors and adolescents' brain activity during violent and non-violent video game play. Findings suggest that empathy and helpfulness are associated to adolescent asymmetric brain activation in response to different video game content. Support was found showing differential pattern of electrical activation unique to game content in relation to prosocial characteristics, but further research is warranted to identify underlying mechanisms responsible for the differential response.

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