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The roles of selective attention and desensitization in the association between video gameplay and aggression: An ERP investigation

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ABSTRACT

A number of studies have indicated that violent video gameplay is associated with higher levels of aggression and that desensitization and selective attention to violent content may contribute to this association. Utilizing an emotionally-charged rapid serial visual presentation (RSVP) task, the current study used two event-related potentials (ERPs) – the N1 and P3 – that have been associated with selective attention and desensitization as neurocognitive mechanisms potentially underlying the connection between gameplay and higher levels of aggression. Results indicated that video game players and non-players differed in N1 and P3 activation when engaged with emotionally-charged imagery. Additionally, P3 amplitudes moderated the association between video gameplay and aggression, indicating that players who display small P3 amplitudes also showed heightened levels of aggression. Follow-up moderational analyses revealed that individuals who play games for many hours and show more negative N1 amplitudes show smaller P3 activation. Together, our results suggest that selective attention to violent content and desensitization both play key roles in the association between video gameplay and aggression.

1. . Introduction

In 2016, approximately 134 million Americans (average age of 35 years) reportedly played video games at an average rate of 3 or more hours per week (Entertainment Software Association, 2016), suggesting that gaming exists as an irrevocably intrinsic part of modern American culture. While it would be inaccurate to generalize the content of any medium as totally violent, content analyses from the 1980's and 90's revealed the most popular video gaming mediums of their time – arcade and console, respectively – were made up of mostly violent content (Braun and Giroux, 1989; Dietz, 1998). Further, the majority of today's apparent best-selling video games are violent (National Purchase Diary Group, 2015, 2016; Entertainment Software Rating Board, 2016), as is the content of many of video gaming's most influential and historically significant titles (Chaplin, 2007), suggesting that people who play video games could be exposed to violence at a greater rate than people who abstain from gameplay altogether. In America – a nation that deals with unique types of mass murderers (Lankford, 2015) and whose citizens are 20 times more likely to be killed by a gun than is someone from another developed country (Fisher, 2012) – debate amongst scholars and the public alike about the link between violent video gameplay and violent behavior has intensified over the years, coming to a head with the *Brown v. EMA* Supreme Court Case in 2011 (Ferguson and Kilburn, 2010; Bushman and Anderson, 2011; Ferguson, 2014; Bushman and Huesmann, 2014).

Despite skepticism about the precise role of media content consumption in causing aggressive outcomes or increasing aggressive thoughts and behavior, numerous studies have indeed revealed an association between exposure to media violence and higher levels of aggression (Anderson and Bushman, 2001; Anderson et al., 2010). Some theories have suggested that desensitization – the flattening of emotional and physiological responses to a stimulus (Funk, 2005) – underlies this association (Dill, 2013). More specifically, the process of emotional desensitization to arousing events has been shown to be associated with a reduced sympathetic skin conductance response to violent movies and portrayals of real life aggression in children who were previously exposed to violent media (Cline et al., 1973; Thomas et al., 1977). Carnagey et al. (2007) also found that participants displayed a decrease in skin conductance, as well as heart rate variability, when viewing violent images after being exposed to violent films, further suggesting a physiological basis for emotional desensitization to violent imagery.

Over the course of the past decade, many studies have also begun to utilize neuroscientific imaging techniques, e.g. event-related potentials

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(ERP) and functional magnetic resonance imaging (fMRI), to more thoroughly investigate potential underlying neurocognitive mechanisms of desensitization (for a review, see Bartholow and Hummer, 2014). One such seminal neuroimaging study by Weber et al. (2006) showed that violent interactions (e.g. shooting other characters) compared to non-violent interactions in a video game were associated with lower levels of amygdala activity, a brain region known to reflect processing and responding to fear-related emotional information (Stockdale et al., 2015). Similarly, Bartholow et al. (2006) observed the same phenomenon through the analysis of P3 amplitudes – a posterior ERP with a peak latency of 300–500 ms after stimulus onset and that has been shown to reflect the activation of the aversive motivational system when evoked by negative information (Cacioppo et al., 1994; Ito, 1998; Hajcak, 2012) – to explore the neurophysiological correlates underlying emotional desensitization. They found decreased P3 amplitudes for video game players compared to non-players when passively viewing violent imagery during an oddball task, and these decreases were further shown to be associated with elevated levels of aggression.

Research suggests that most people typically respond to violence with avoidance-related motivational strategies; thus, aversive responses such as anxiety, fear, or feelings of discomfort are most common (Cantor, 1998; Anderson and Dill, 2000; Bartholow et al., 2006). However, given the absence of any apparent consequence, like pain, and the positive context in which video games often frame violence (i.e. harming or killing others in pursuit of further achievement), it is theorized that individuals emotionally desensitized to violence experience an approach-avoidance conflict, adopting more aggressive, approach-related strategies when faced with depictions of violence (Bandura et al., 1967; Epstein, 1978; Linz et al., 1988).

In this same vein, research has also suggested that individuals will actively seek to alter their environment to regulate their affective state, including by means of selectively exposing themselves to particular media content (Zillmann, 1988). For example, Krahé et al. (2011) took a psychophysiological approach towards examining how the absence of negative affectivity in the face of depictions of violence opens individuals up to experiencing different affective states in atypical circumstances, such as feeling pleasure while viewing violence. In an experiment that used skin conductance levels as its primary measure while participants watched violent video clips, their results revealed that high violent media exposure was correlated with low skin conductance levels but high levels of positive affect. In line with research showing that fearful individuals prefer films with lower victimization scores (Wakshlag et al., 1983) and bored individuals selectively seek out exciting television programming (Bryant and Zillmann, 1984), it has been suggested that individuals who are characteristically low in affective arousal might seek out "thrilling" content as a means of adjusting their arousal to satisfactory levels (Zillmann, 1988; Huesmann and Kirwil, 2007). Further, Slater (2007) has proposed that the selection of an individual's media content and the resulting subsequent attitudinal or behavioral outcomes affecting its consumption reinforce each other. Thus, a video game player might choose to expose himself/herself to violent content for "thrills," remember violence as an enjoyable experience, and become more inclined to select that same sort of media again in the future (Whitaker, 2013).

Despite this theoretical foundation, however, more detailed accounts of the specific cognitive processes that might contribute to the broader process of desensitization and lead to higher levels of aggressive thoughts, feelings, and behavior still remain largely absent. Specifically, the role of selective attention in the context of desensitization and, more broadly, in the association between video gameplay and aggression remains virtually unexplored.

Thus, the current study aims to expand the current literature by 1) examining differential patterns of ERP activation related to selective attention and desensitization between video game players and non-players, 2) examining the role of selective attention and desensitization to violence in the association between video gameplay and aggression, and 3) lastly, explore if selective attention might impact desensitization or vice versa, in the context of gaming behavior. These aims will be examined via analyses of ERPs within the context of a task that presents emotionally-charged images.

We will start by confirming the current literature. More specifically, we will use P3 amplitudes to confirm that deficits in the aversive motivational system, i.e., desensitization, moderate the association between game play and aggression. Consistent with the works of Bartholow et al. (2006), we predict specifically that video game players who have smaller P3 amplitudes in the face of violent content will show higher levels of aggression.

Additionally, we will examine N1 amplitudes, an early sensory ERP component occurring at posterior midline sites at rough 150 ms after stimulus onset. The N1 has been associated with selective attention (Coull, 1998; Vogel and Luck, 2000; O'Donnell et al., 2012). Several ERP studies of visuospatial attention have shown that attention can influence processing within 100 ms of stimulus onset (Vogel, Luck and Shapiro, 1998; Hillyard and Anllo-Vento, 1998), showing that attended-location stimuli elicit larger amplitudes in early sensory components than ignored-location stimuli. Additionally, several studies have shown that N1 amplitudes are sensitive to emotional valence (e.g., Foti and Hajcak, 2008; Foti et al., 2009). Thus, more negative N1 amplitudes, in the context of negative imagery, might be indicative of a negative selective attentional bias amongst video game players.

To measure N1 and P3 amplitudes, participants in the current study – video game players and non-players – performed an emotionally charged, Rapid Serial Visual Presentation (RSVP) task. Although past ERP research has used other cognitive tasks, like the oddball task (Bartholow et al., 2006), we used a task that better emulated a real-world gaming environment because it presented target images in the context of rapidly presented distractor stimuli, similar to actual video games. Specifically, we used an RSVP task that presents players with two targets embedded in a stream of 17 complex stimuli (Raymond, Shapiro, and Arnell, 1992) instead of just a single, briefly exposed target, outside of any other stimuli. To the best of our knowledge, the task has only been used once before in the context of a gaming study (Green and Bavelier, 2003) and never in the gaming and aggression literature. The task has, however, been extensively used in the context of the Attentional Blink literature (e.g., Most et al., 2005; Raymond and O'Brien, 2009; Raymond et al., 1992). According to past theory, an attentional blink is generated when an emotionally challenging stimulus requiring substantial attentional resources is presented shortly before a stimulus requiring action. The second stimulus is "blinked" likely because there are insufficient attentional resources left to encode the information in working memory (e.g., Most et al., 2005; Shapiro et al., 2006). In line with the Most et al. (2005) attentional blink task, our task presented participants with two target images, of which the first one consisted of negative images (73% of which were violent in nature) or neutral images, and the second one, presented shortly after the first one, required participants to provide a behavioral response. Thus, given the nature of this task, i.e., having to selectively attend to key images within the context of other distracting images (selective attention) and that this process of selecting emotionally-charged information may influence downstream neural arousal, we believed this task would be ideal for testing if selective attention and desensitization moderate the association between game play and aggression.

2. Materials and methods

2.1. Participants

Participants were undergraduate students (n = 67; 24 male; 32 video game players; 35 non-players) who attended the University of New Orleans. Participants ranged in age from 18 to 41 (mean age = 22.29; SD of age = 5.21). Video game players and non-players did

Table 1
International Affective Picture System (IAPS) images used within the Rapid Serial Visual Presentation (RSVP) task.

Category	ID
T1 Neutral	1333, 7002, 7052, 5532, 7045, 7100, 3266, 1661, 5740, 7061, 5530, 5875, 7140, 1670, 6150, 7150, 5500, 7040, 7130, 1903, 7000, 7175, 2005, 7001, 7211, 5471, 7032, 7090, 2102, 7003, 7300, 5395, 7030, 7081, 2107, 7004, 7512, 2305, 7006, 7705, 2372, 7009, 7950, 2392, 7010, 8312, 2394, 7012, 8465, 2506, 2513, 7019, 7513, 7021, 7509, 7217, 5040, 7025, 7236, 5390, 7026
T1 Negative	1120, 3080, 6510, 3069, 9410, 1205, 3101, 6520, 1300, 3102, 6563, 1525, 3110, 6570, 1930, 3130, 9006, 2352, 3168, 2661, 3170, 9042, 2717, 3225, 9043, 2800, 3261, 9075, 3000, 3400, 9185, 3010, 3550, 9253, 3001, 6230, 9325, 3015, 6002, 9405, 3030, 6231, 9570, 3051, 6243, 9590, 3053, 6250, 9635, 3059, 6313, 9490, 3060, 6315, 9571, 3062, 6350, 9520
Distractor Neutral	2830, 5535, 7057, 2026, 2499, 7290, 7700, 1121, 2309, 2580, 4100, 7020, 7161, 7490, 8118, 1350, 2635, 8117, 9422, 7170, 2411, 5534, 2036, 7096, 2840, 5455, 7550, 7233, 2359, 4274, 2273, 2870, 7283, 9260, 5130, 5250, 5665, 2230, 7050, 7002, 2104, 2890, 2493, 2384, 2512, 7110, 2594, 7039, 7053, 2002, 7033, 5661, 7710, 1122, 2455, 7595, 7285, 2032, 4573, 2485, 7017, 2272, 7546, 5533, 2397, 7207, 7055, 5410, 6837, 2489, 7590, 7235, 2850, 7255, 7018, 2518, 8010, 7504, 2211, 7402, 2385, 1850, 2488, 5510, 7503, 7044, 2200, 2441, 7045, 8311, 7014, 8121, 5520, 7351, 2235, 2191, 7506, 2279, 1675, 2435, 3069, 2880, 2215, 2749, 7160, 9070, 7476, 2446, 2377, 4536, 2484, 7187, 2190, 2620, 8325, 1645, 2390, 2702, 7034, 2382, 7062, 2980, 7016, 4605, 4571, 7190, 2440, 2101, 7042, 8211, 1616, 2514, 2280, 2593, 2221, 7365, 8241, 2595, 2393, 2038, 7041, 2308, 2210, 2410, 2579, 5120, 7037, 7180, 7493, 7547, 2214, 2516, 7035, 7179, 7477, 2396, 2575, 2597, 7036, 7095, 7487, 7205, 2495, 2521, 7038, 7080, 7224, 2515, 7060, 7077, 7058, 7043, 7484, 7234, 7056, 2487, 7192, 5900, 7560, 9210, 2383, 7461, 2600, 2445, 7031, 7059, 5731, 2357, 7185, 7165, 5531, 1947, 7011, 2480, 7620, 7354, 7287, 2020, 2570, 2381, 2745

not differ significantly in age, $t(64) = -.55$, $p = .58$, sex, χ2 (1, N = 67 = .62, p = .43, ethnicity/race, χ2 (4, N = 67) = 3.71, p = .45, or household yearly income, χ2 (5, N = 67) = 1.402, p = .92. All participants had normal or corrected-to-normal vision, had a hair style that was conducive to EEG data collection procedures, and were free of current psychiatric diagnoses. In total, 114 participants took part in the study. One participant, who reportedly played video games for 40 h per week, was excluded from the analysis as an outlier. Forty-six other participants were excluded from the study for a number of reason: 1) insufficient number of trials to make an ERP, largely due to poor performance, 2) hairstyles that were not conducive to EEG research, or 3) equipment failure. Thus, the final sample size used for statistical analyses was 67 (24 male). Included and excluded participants did not differ significantly in age, $t(110) = .63$, $p = .53$, sex, χ2 (1, N = 113) = .71, p = .40, ethnicity/race, χ2 (6, N = 113) = 7.79, p = .26, video gameplay status, χ2 (1, N = 113) = 2.58, p = .11, or household yearly income, χ2 (5, N = 113) = 1.792, p = .88. Participants were recruited through undergraduate classes and earned course credit for their participation. This study received IRB approval from the University of New Orleans.

2.2. Procedure

After obtaining written consent, questionnaires were completed and participants were seated 67 cm from a computer monitor. Instructions on how to do the task were given, and participants completed a practice block – identical to the main task – of 10 trials. When participants indicated that they understood the requirements of the task, they went on to perform the actual task. On average, the task took 30 min to complete.

2.3. Measures

2.3.1. Demographics questionnaire

Data on ethnicity/race, age, sex, parental education, household yearly income, and basic video gameplay habits (i.e. Do you play video games? If so, for how many hours a week on average?) were collected using a demographics questionnaire. Anyone who indicated that they played video games were coded as video game players (mean hours per week = 4.72; SD = 4.09). Anyone who said they did not play video games (0 h) were coded as non-video game players.

2.3.2. Buss-Perry Aggression Scale (Anderson and Dill, 2000; Buss and Perry, 1992)

The Buss-Perry Aggression Scale is a 29-item self-report measure that has been deemed to be both reliable and valid. All 29 items were averaged to yield an overall aggression score.

2.4. Task

This study used a Rapid Serial Visual Presentation (RSVP) task – specifically, an attentional blink paradigm. Raymond et al. (1992) were the first to coin the phrase attentional blink (AB)—a psychological construct in which attention is momentarily inaccessible due to the processing of previous information. When two targets are to be identified among non-target distractors, most individuals show an AB in reporting the second target. Correct identification of the first target (T1) impedes the detection of a second target (T2) that appears within 500 ms of T1 (Chun and Potter, 1995; Raymond et al., 1992). The failure to report a T2 is believed to happen because a large amount of attentional resources have been allocated to T1 (Shapiro et al., 2006). The attentional blink is believed to be induced when salient stimuli cause a focus of attention. This task was adapted from a previous version (Most et al., 2005) and presented using E-Prime software (Schneider et al., 2002). T1 events consisted of a balanced number of negative (73% violent) and neutral pictures from the International Affective Picture System (IAPS; Lang et al., 2008; See Table 1 for a list of IAPS images used) presented pseudo randomly (trials were presented in the exact same order for every participant). Negative and neutral images were chosen based on the IAPS criteria of valence and arousal (Lang et al., 2008), with negative pictures being both highly negatively valenced and highly arousing and neutral pictures falling roughly in the middle of the valence scale. Given these criteria of high arousal and negative valence, the majority of negative images revealed to be violent in nature. Each T1 picture was surrounded with a yellow frame to differentiate these images from the neutral distractor images (see Fig. 1). Trials consisted of a RSVP stream of 17 black and white images, presented for 75–120 ms, and jittered trial-by-trial to avoid ERP artifact. Depending on the trial, T1 was presented as the 4th, 6th, or 8th stimulus. T2 was presented either two or eight pictures after T1 (lag 2 and lag 8). T2 events were pictures of houses either tilted 90 degrees to the left or to the right. Neutral distractor photos did not include any house photos, to prevent confusion. At the end of each RSVP stream, participants were asked if the T2 (house picture) was tilted to the left or the right. Participants had an infinite amount of time to respond. Participants had to press the left (button 1) or right (button 4) button on a button box to indicate direction of house tilt. House pictures were drawn from publicly available sources. In order to make missed or "blinked" T2 trials a viable option, 1/6 of trials did not have a T2 event. Thus, participants were also given the option to indicate that no house was presented by pressing button 3. To best capture neural mechanisms contributing to the attentional blink, ERP data were only analyzed for

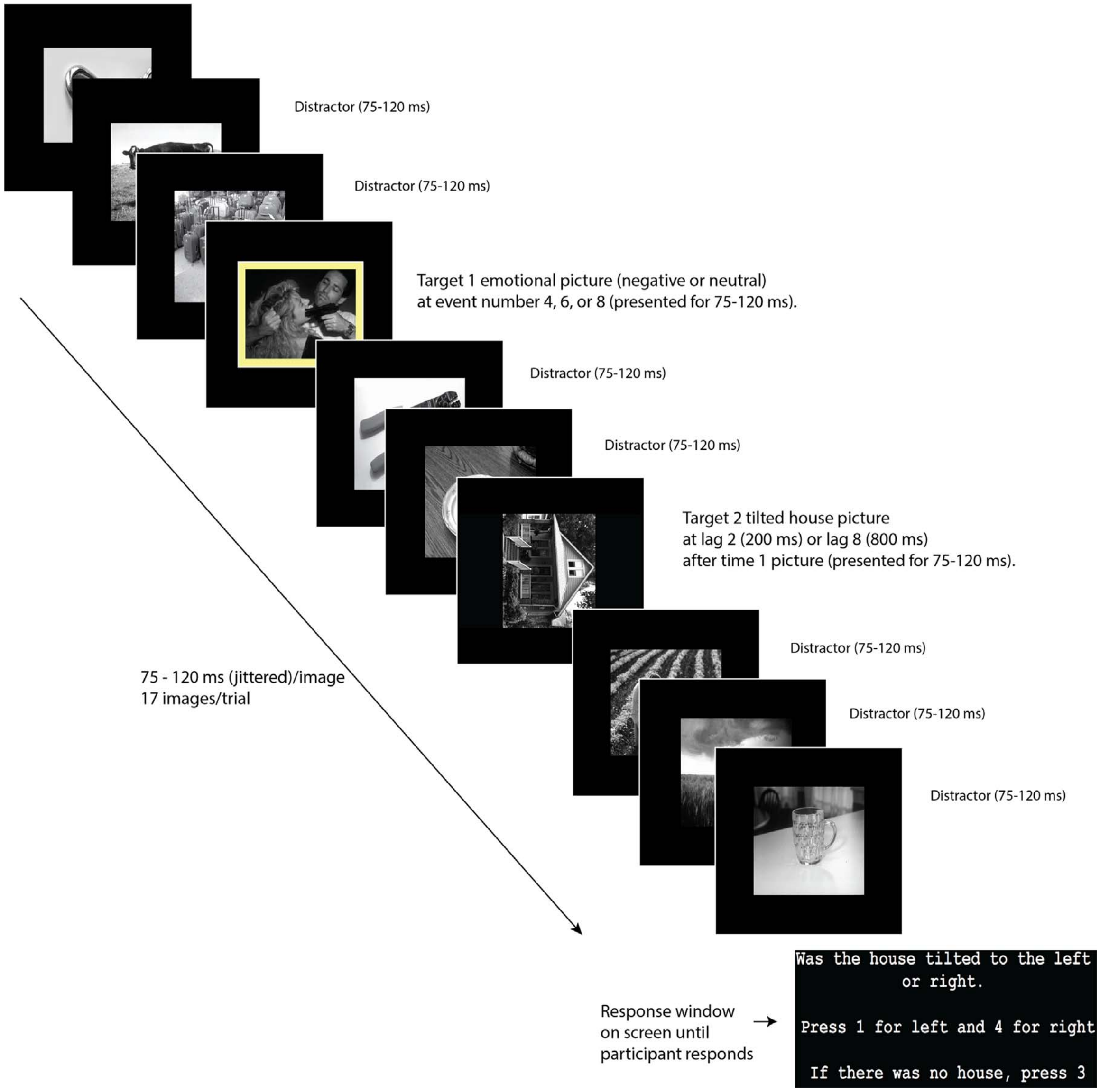

Fig. 1. RSVP Task.

error trials in which a house (T2) was presented but the participant erroneously believed no house was presented (erroneously press button 3 when a house was really presented). However, for behavioral data, overall task performance accuracy was analyzed. To prevent participants from looking at their hands to indicate the correct button, which would lead to EEG eye artifact, button 3 was marked by a large fuzzy sticker, which could easily be identified by touch alone. The task consisted of 4 blocks of 120 trials each, of which 25 were neutral lag 2 trials, 25 were negative lag 2 trials, 25 were neutral lag 8 trials, 25 were negative lag 8 trials, 10 were neutral no T2 trials, and 10 were negative no T2 trials.

2.5. EEG data collection and analyses

EEG was recorded using a 128-channel Geodesic Sensor Net and sampled at 250 Hz, using EGI software (Net Station; Electrical Geodesic, Inc., Eugene, OR). Net Station was also used for data analyses. Data acquisition was started after all impedances for all EEG channels were reduced to below 50 kΩ. All channels were referenced to Cz (channel 129) during recording and were later re-referenced against an average reference corrected for the polar average reference effect (PARE correction; Junghöfer et al., 1999). Data was filtered using a FIR bandpass filter with a lowpass frequency of 50 Hz and a highpass frequency of .3 Hz. To best capture eye blink artifacts, the threshold was set to 140 μV threshold (peak-to-peak) and all trials in which this threshold was violated were excluded from analyses. Furthermore, signal activation change (peak-to-peak) exceeding 100 μV across the entire segment were marked as bad and interpolated. Baseline correction for all ERP components was 150 ms before time locking (either T1 or T2) stimulus onset. ERP component time ranges were based on the grand averaged waveform. The same electrode montages and time ranges (from specific time locking stimulus) were used for T1 and T2 stimuli. All ERP component values analyzed were maximal activation across time, most negative for N1 (100–200 ms) and most positive for P3 (450–750 ms; see Fig. 2 for waveforms). All ERP activation analyzed was comprised of the average activation across clusters of electrodes (see Fig. 3) from electrode montages pre-specified by the literature: N1 occipital (Farroni et al., 2002; Vogel and Luck, 2000) and P3 parietal clusters (Ila and Polich, 1999; Katayama and Polich, 1999). Participants whose ERP components were made up of less than 8 trials were excluded from statistical analyses: error T1 neutral trials (Mean = 26.82 SD = 11.62), error T1 negative trials (Mean = 21.84 SD = 10.39), error T2 neutral trials (Mean = 27.34 SD = 11.85), and error T2 negative trials (Mean = 22.04 SD = 10.49).

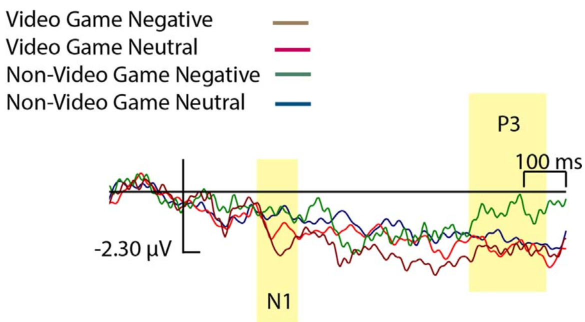

Fig. 2. Waveforms time-locked to T1 error trials, errors in which a house was present but not perceived by the participant. Positive activation is up. Waveform shows activation at electrode 72.

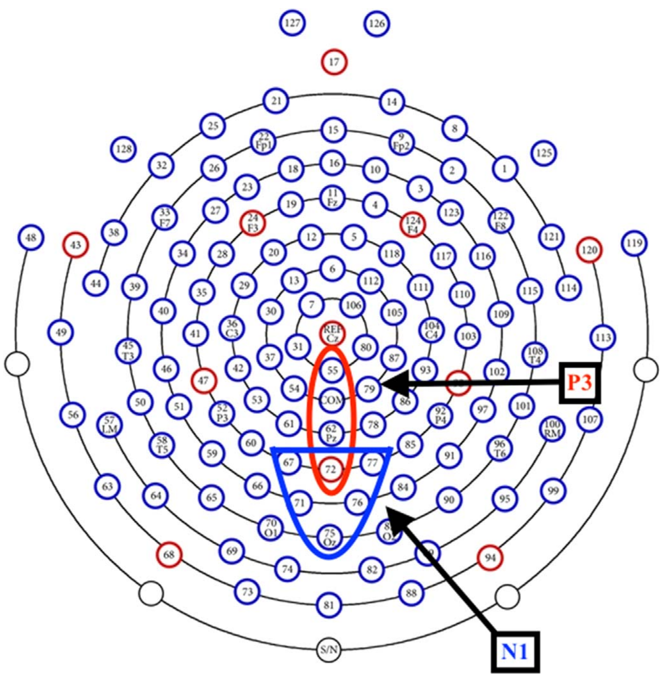

Fig. 3. ERP electrode montage.

2.6. Statistical analyses

For all analyses, we collapsed across trials that consisted of houses tilted right or left. To verify effectiveness of the task, we first examined performance accuracy differences for lag 2 and lag 8 trials. Previous research has shown that the attentional blink phenomenon occurs roughly 200–500 ms after the T1 is presented (For a review, see Martens and Wyble, 2010). Therefore, we predicted that lag 8 trials would show better performance accuracy than lag 2 trials. Indeed, this was the case: neutral = t(66) = 4.17, $p < .001$; negative = t(66) = 6.63, $p < .001$. These results suggest that we administered the attentional blink task effectively. All subsequent analyses will be conducted on Lag 2 trials since Lag 8 trials were only included to test the effectiveness of the task.

Given our theoretical model and very specific hypotheses we are only going to analyze two ERPs (P3 and N1) in the context of neutral and negative error trials: 1) P3 to measure desensitization and 2) N1 to measure selective attention. N1 and P3 activation will both be measured time locked to the T1 condition because these mechanisms are best measured in the context of salient images. Since deficits in either of these mechanisms would lead to an erroneous response, we are only examining error trials in which a house was presented but the participant did not perceive the house, likely due to an attentional blink. We are not examining ERPs to errors due to random responding or confusion about the direction of the house.

Independent samples *t*-tests were used to test for sex differences amongst all variables of interest and yielded no significant differences. Therefore, we proceeded without entering sex as a predictor or interaction term in any of our analyses.

3. Results

3.1. Group differences

3.1.1. Behavioral analyses

To ascertain if there were group differences in overall performance accuracy (i.e. accuracy rate), data were analyzed with a 2 (video game player vs. non-player) by 2 (neutral emotional condition vs. negative emotional condition) mixed model ANOVA. Results revealed a significant main effect of condition, $F(1, 65) = 36.32$, $p < .001$, with participants responding significantly more accurately in the neutral condition ($M = .63$, $SE = .02$) than negative condition ($M = .69$, $SE = .01$). There was, however, no significant main effect of video gameplay status, $F(1, 65) = .253$, $p = .62$, or interaction of video gameplay status and condition, $F(1, 65) = .829$, $p = .37$, on performance accuracy.

Additionally, we conducted a univariate ANOVA to examine the relationship between video gameplay and aggression. Results revealed no significant difference between video game players and non-players in trait aggression, $F(1, 65) = 1.853$, $p = .18$.

3.2. ERP analyses

We conducted 2 (Group: video game players vs. non-players) by 2 (Condition: negative vs. neutral) mixed design ANOVAs separately on T1 N1 and T1 P3 activation. Results indicated a trend-level main effect of video gameplay status on N1 amplitudes, $F(1, 62) = 3.49$, $p = .06$, with video game players displaying more negative N1 amplitudes than non-video game players ($MD = -.60$, $SE = .32$). Results also revealed a trend-level Group by Condition Interaction for P3 amplitudes, $F(1, 63) = 3.47$, $p = .06$. Bonferroni corrected contrasts revealed that video game players displayed significantly lower P3 amplitudes than non-players in the negative condition ($p = .04$). Furthermore, while non-video game players displayed significantly higher P3 amplitudes in the negative condition than the neutral condition ($p = .03$), video game players displayed no such significant difference between negative and neutral conditions ($p = .64$). Thus, consistent with previous literature (Weber et al., 2006; Bartholow et al., 2006; Engelhardt et al., 2011), these results suggest that video game players process negative stimuli differently than non-players (see Fig. 4).

3.3. Brain data moderational analyses

We conducted a number of moderational analyses. For these analyses, we entered all independent variables to test for main effects. We also entered interaction terms between all independent variables. For example, if the analysis required three independent variables, we would generate three separate 2-way interaction terms between the independent variables and enter these into the model. Additionally, for this example model, we would generate a 3-way interaction term and entered it last into the model. Lastly, our aggression measure comprised the dependent variable. To avoid multi-collinearity, continuous predictor variables were mean centered and interaction variables were calculated as product terms of the mean-centered predictors in all moderational analyses (Aiken and West, 1991). Any significant or trend-level interaction terms were then decomposed by recalculating ERP activation into new variables representing high activation and low activation and running additional regression analyses using the re-calculated scores, as suggested by Aiken and West (1991). Given that

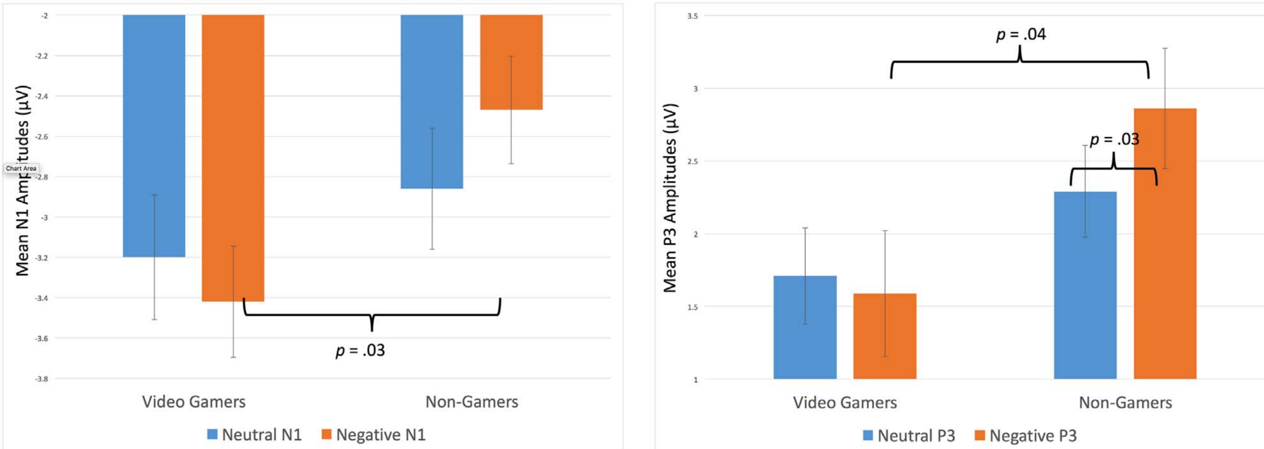

Fig. 4. Bar graphs of P3 (left) and N1 (right) Amplitudes for video gamers and non-gamers by condition.

group differences were found almost entirely for the negative condition and not the neutral condition, all moderational analyses outlined below are for the negative condition.

3.4. Moderational analyses on aggression

As outlined above, linear regression was used to test the theory that desensitization (T1 P3 amplitude) and/or selective attention (T1 N1 amplitude) moderates the association between video gameplay (yes/no response) and aggression (Engelhardt et al., 2011). To reduce the risk of type-1 error due to multiple comparisons, both P3 and N1 amplitudes were entered in the same model. Results of this analysis confirmed that video gameplay was not significantly associated with aggression (no main effect), $\beta = .161$, $t\ (60) = 1.28$, $p = .21$. As well, P3 amplitudes, $\beta = .161$, $t\ (60) = .97$, $p = .34$, and N1 amplitudes, $\beta = .224$, $t\ (60) = 1.31$, $p = .19$, had no significant effect on aggression. Furthermore, N1 amplitudes-by-gaming behavior, $\beta = -.088$, $t\ (60) = -.52$, $p = .61$, and the combined N1 amplitudes-by-P3 amplitudes-by-gaming behavior, $\beta = -.054$, $t\ (59) = -.356$, $p = .72$, did not significantly predict aggressive behavior. However, P3 amplitudes did significantly interact with video gameplay on aggression, $\beta = -.385$, $t\ (60) = -2.31$, $p = .02$.

The significant interaction term (P3 by video gameplay on aggression) was decomposed as outlined above. Results indicated that the association between video gameplay and aggression was only significant for those who displayed low levels of P3 amplitude in the negative condition, $\beta = .45$, $t\ (63) = 2.63$, $p = .01$ (see Fig. 5). These results suggest that players who display small P3 amplitudes also show heightened levels of aggression. However, this effect was not found for individuals who showed high levels of P3 activation, $\beta = -.18$, $t\ (63) = -.99$, $p = .33$.

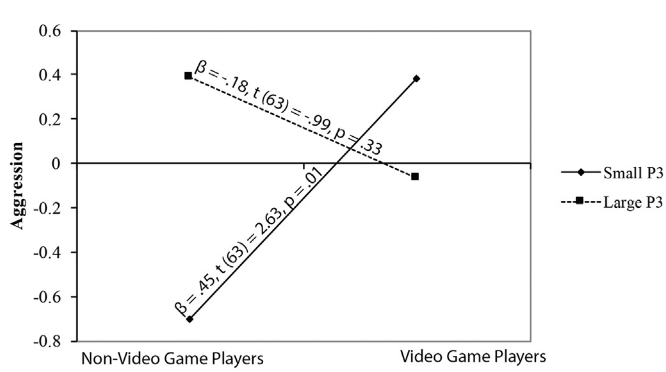

Fig. 5. Moderation plots: Interaction between Video Gameplay and P3 amplitude on aggression.

3.5. Moderational analyses of a reinforcing spirals theory

Given Slater's (2007) model of reinforcing spirals, we also examined the impact of N1 and P3 amplitudes, i.e., selective attention and desensitization, on each other. Slater (2007) proposed that the selection (selective attention) of an individual's media content and the resulting subsequent attitudinal or behavioral outcomes (desensitization) affecting its consumption reinforce each other. We focused this analysis only on the video game players because our non-gamers reported zero hours of gaming and therefore had insufficient variance. Thus, we conducted hierarchical linear regression analyses to test if N1 amplitudes in the context of violent imagery (selective attention to violence) moderate the association between hours per week spent playing video games and P3 amplitudes (desensitization to violence), and vice versa, i.e., if P3 amplitudes moderate the association between hours per week spent playing video games and N1 amplitudes. Results of these analyses, indeed, revealed a significant interaction of gaming hours-by-N1 amplitudes on P3 amplitudes, $\beta = .57$, $t\ (27) = 2.64$, $p = .01$ (see Fig. 6). However, the gaming hours-by-P3 interaction term was not associated with N1 amplitudes, $\beta = .063$, $t\ (27) = .344$, $p = .73$. Thus, simple slopes were used only to decompose the gaming hours-by-N1 amplitudes interaction on P3 amplitudes. Results revealed that individuals who played video games for a larger amount of time and had elevated (more negative) N1 activation (selective attention) showed the greatest deficits in P3 activation (desensitization), $\beta = -.77$, $t\ (27) = -2.41$, $p = .02$. Further, individuals who played games for a larger amount of time and had reduced (less negative) N1 activation showed the greatest levels of P3 activation, $\beta = 1.26$, $t\ (27) = 2.64$, $p = .01$. While both slopes were revealed to be significant, the key finding here

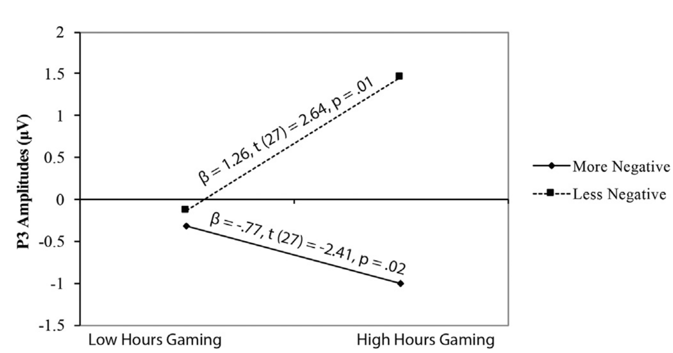

Fig. 6. Moderation plots: Interaction between Video Gameplay and N1 amplitude on P3 amplitude.

is that high frequency gamers who have more negative N1 activation (more selective attention to violence) show smaller P3 amplitudes, suggestive of greater desensitization.

4. Discussion

Much of the previous literature has suggested that the association between video game play and aggressive tendencies might be brought about by deviations in emotional desensitization (Cline et al., 1973; Bartholow et al., 2006; Carnagey et al., 2007) and selective attention (Zillmann, 1988; Slater, 2007). Therefore, the current study examined how these mechanisms (desensitization and selective attention) moderate the association between gameplay and aggression. To address this question, we used an emotionally-charged RSVP paradigm to examine ERP activation differences between video game players and non-players in the face of negative, largely violent, pictures. Unlike previous media violence studies, which have focused largely on P3 amplitudes as a physiological measure reflective of a blunted aversive motivational system (i.e., desensitization; Bartholow et al., 2006), we also tested N1 amplitudes to investigate the role of selective attention in the association between video gameplay and aggression.

Consistent with past findings and theory (e.g., Engelhardt et al., 2011), video game players showed blunted P3 amplitudes. Amongst these players, decreased P3 amplitudes were indeed associated with higher levels of aggression, suggesting that desensitization to violent imagery underlies the association between video gameplay and aggression. Along with P3 activation differences, N1 activation differences were also observed between video game players and non-players. Previous research has suggested that N1 activation is particularly sensitive to emotionally-valenced (Foti and Hajcak, 2008) and attention-grabbing stimuli (Vogel et al., 1998). Overall, gamers showed more negative N1 activation than non-gamers for both negative and neutral trials, but the effect was slightly greater for the negative condition, potentially suggesting a selective attentional bias to violent stimuli.

Results also indicated that N1 amplitudes had no moderating effect on aggression. However, given Slater's (2007) model of reinforcing spirals, we conducted follow-up analyses to see how P3 (desensitization) and N1 (selective attention) activation might interact to reinforce each other. Our findings suggest that – for our game playing sample – selective attention to negative stimuli (N1 amplitudes) moderated the association between hours spent playing video games and desensitization (P3 amplitudes), but desensitization did not moderate the association between hours spent playing video games and selective attention. Thus, high frequency game players with a selective attentional bias to violent content show the highest levels of desensitization. Although we did not find support for a reinforcing spirals theory, in which desensitization increases the likelihood a video game player will select violent content (Slater, 2007), our results suggest that higher levels of violent content selection might increase desensitization effects. While these results do not indicate causality because they were measured at the same time, they are novel and thus interesting, and future research should explore if selectively attending to violent imagery might cause emotional desensitization. If selective attention were to contribute to emotional desensitization, future research should explore if attention-training approaches might decrease levels of emotional desensitization.

5. Limitations

There are limitations to the current study. First, video games are a medium comprised of a vast array of content available through a host of platforms in various genres. However, a video game violence meta-analysis of 101 studies conducted by Ferguson (2014) highlights the ambiguity of how the field has assessed "violent" video game content to date. Specifically, the author suggests that variability in characterizations of violent content across studies limits the generalizability of these effects (e.g. he notes that both Pac Man and Call of Duty could be considered "violent" in different studies). Other researchers have indicated similar concerns as well, noting that no reliable and valid assessment of video game content has been developed (Anderson et al., 2010; Busching et al., 2015). Thus, to avoid adding to the ambiguity in the literature, we decided to use a simple, broad, binary measure that did not specify the precise content consumed by video game playing participants. It is important that future research aims to norm a media content measure that is capable of consistently assessing video game content.

As well, it should be reiterated that the current study's presented images were chosen on the criteria of valence and arousal, as they were taken from the IAPS image inventory. Thus, although the images were all highly negatively valenced and highly arousing, some were not necessarily violent in nature. The current study also utilized questionnaire data to measure aggression. Questionnaire data can often be disingenuous due to biases brought about by social desirability. Future studies should at least implement a social desirability questionnaire as a control variable. Ideally, future studies should also aim to use in-lab behavioral measures of aggression as outcome variables.

Finally, while the RSVP task was deemed to be a more realistic task to explore gaming behavior, the task is quite complex and therefore requires considerable trials to fulfill all the required conditions. To prevent the task from becoming overly tiring, we had to limit the number of trials fulfilling each condition. Thus, we lost a number of participants simply because they did not yield enough trials for one condition or another.

6. Conclusions

Our results suggest that video game players experience greater levels of desensitization to negative, potentially violent imagery, which contributes to higher levels of aggression. Notably, video game players in our sample also displayed a selective attentional bias to violent content, which moderated levels of desensitization to violence. Together, these findings highlight the potentially dangerous side effects of violent content consumption for individuals, which could be especially deleterious within societies whose populations frequently indulge in such content. Desensitization to media violence has been shown to extend to how we empathize with victims of violence in news reports (Scharrer, 2008), and there is some evidence that suggests that selecting digital war games, like Call of Duty, may promote pro-war sentiments (Leonard, 2004; Debrix, 2008; Šisler, 2009; Gagnon, 2010). Therefore, in a time in which our media interactions carry important sociopolitical implications, it is essential that we continue to work towards a more complete understanding of the cognitive processes, such as selective attention and desensitization, underlying our thoughts and behavior.

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