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Journal of Experimental Social Psychology 42 (2006) 532–539
Journal of Experimental Social Psychology
www.elsevier.com/locate/jesp

Chronic violent video game exposure and desensitization to violence: Behavioral and event-related brain potential data ☆

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Received 21 April 2005; revised 26 July 2005
Available online 7 October 2005

Abstract

Numerous studies have shown that exposure to media violence increases aggression, though the mechanisms of this effect have remained elusive. One theory posits that repeated exposure to media violence desensitizes viewers to real world violence, increasing aggression by blunting aversive reactions to violence and removing normal inhibitions against aggression. Theoretically, violence desensitization should be reflected in the amplitude of the P300 component of the event-related brain potential (ERP), which has been associated with activation of the aversive motivational system. In the current study, violent images elicited reduced P300 amplitudes among violent, as compared to nonviolent video game players. Additionally, this reduced brain response predicted increased aggressive behavior in a later task. Moreover, these effects held after controlling for individual differences in trait aggressiveness. These data are the first to link media violence exposure and aggressive behavior to brain processes hypothetically associated with desensitization.

Keywords: Aggression; Desensitization; Violent media; Event-related potential ERP; Habituation; P300; Brain; Video games

Introduction

Most people naturally have aversive reactions to the sight of blood and gore. Some people (e.g., soldiers, surgeons) must overcome these reactions in order to effectively perform their duties. This example illustrates the process of desensitization, defined as diminished psychological or emotional responsiveness to a stimulus after repeated exposure to it (see Wolpe, 1982). Desensitization can be adaptive because it enables people to ignore irrelevant information and focus instead on relevant information. For most people, however, becoming desensitized to blood and gore can have deleterious social consequences, such as reducing inhibitions against behaving aggressively.

Hundreds of studies have shown that exposure to media violence increases aggression (see Anderson & Bushman, 2001; Anderson et al., 2003). Media violence is believed to increase aggression, at least in part, by desensitizing viewers to the effects of real violence (e.g., Griffiths & Shuckford, 1989; Smith & Donnerstein, 1998). Media violence initially produces fear, disgust, and other avoidance-related motivational states (Cantor, 1998). Repeated exposure to media violence, however, reduces its psychological impact and eventually produces aggressive approach-related motivational states (Cline, Croft, & Courrier, 1973; Linz, Donnerstein, & Adams, 1989), theoretically leading to stable increases in aggression.

Extant research on media violence desensitization has been limited in a number of respects. For example, although

☆ We thank Bill Gehring and Johan Hoorn for their helpful comments on an earlier version of this article. Portions of this work were presented at the 2005 annual meeting of the Society for Personality and Social Psychology.
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doi:10.1016/j.jesp.2005.08.006

desensitization is believed to have both cognitive and emotional components (see Funk, Bechtoldt-Baldacci, Pasold, & Baumgartner, 2004), most research has focused only on the emotional component (see Smith & Donnerstein, 1998). Additionally, very few studies to date have examined how repeated exposure to media violence affects brain processes (but see Kronenberger et al., 2005), and no studies have examined potential links between physiological indices of desensitization and aggressive behavior. Strong support for the desensitization account of media violence effects will be indicated only if processes associated with desensitization can be linked to increases in aggressive behavior.

Theoretically, desensitization should be reflected in the amplitude of the P300 component of the event-related brain potential (ERP). ERPs are voltage deflections in the electroencephalogram (EEG) that reflect the engagement of various information processing activities in the brain (see Fabiani, Gratton, & Coles, 2000). The amplitude of the P300 component of the ERP, often associated with working memory updating (Donchin & Coles, 1988), also has been shown to reflect the extent of evaluative categorization during processing of affective or emotionally relevant stimuli (e.g., Cacioppo, Crites, Berntson, & Coles, 1993; Ito, Larsen, Smith, & Cacioppo, 1998b). Large P300 amplitudes are elicited over midline parietal scalp regions by stimuli that are evaluatively inconsistent with a preceding context (Bartholow, Fabiani, Gratton, & Bettencourt, 2001; Cacioppo et al., 1993; Ito et al., 1998b). For example, infrequent negative target images presented in a context of frequently presented neutral images elicit large P300s (Ito et al., 1998b). It follows, then, that violent images presented in a context of neutral images should also elicit large P300s. To the extent that an individual is desensitized to violence, however, the P300 elicited by violent images should be reduced. Moreover, to the extent that a P300 reduction reflects motivational processes associated with desensitization to violence, the P300 reduction should be restricted to evaluative categorization of violent images and not to negative images more generally.

Furthermore, if desensitization helps to explain the link between media violence and aggression, and if electrocortical responses to violent stimuli reflect desensitization, then decreases in P300 amplitude to violent images should be associated with increases in aggression. A number of studies have shown that the P300 elicited by negative information reflects activation of the aversive/withdrawal motivational system (e.g., Cacioppo, Crites, Gardner, & Berntson, 1994; Ito et al., 1998b). Given that aggression is incompatible with withdrawal motivation (see Harmon-Jones, 2003), and that desensitization theoretically weakens the aversive motivation system pertaining to violence (Cantor, 1998; Funk et al., 2004), there should be an inverse relationship between P300 amplitudes elicited by violent stimuli and indices of aggressive behavior.

Critics of the link between media violence and increased aggression often claim that media violence exposure effects are spurious, masking the effect of some unmeasured third variable such as aggressive personality (Freedman, 2002). In other words, aggressive individuals are simply drawn to violent media. If this hypothesis is correct, controlling for individual differences in aggressive disposition should eliminate or significantly reduce the effects of exposure to media violence on relevant outcomes. Critics also argue that laboratory experiments showing increased aggression following violent media exposure simply reflect a priming effect, likely lasting only a few minutes, which does not carry over into the "real world" (e.g., Fowles, 1999; Freedman, 1984). The desensitization account is at odds with both of these alternative interpretations, predicting that media violence exposure leads people to aggress (not that aggressive people seek out violent media) and that repeated exposure has lasting deleterious consequences. The current study tests these competing interpretations.

In this study, violent and nonviolent video game players completed a visual oddball task in which neutral, violent, and negative nonviolent target images were presented in a neutral image context while ERPs were recorded. Later, participants engaged in a competitive task during which they could blast another "participant" with loud noise; this task was used to measure aggression. We predicted that violent video game players would show deficits in P300 amplitude to violent images, but not to negative nonviolent images, relative to nonviolent game players. We further predicted that violent game players would behave more aggressively in the competitive task, and that P300 amplitudes to violent (but not nonviolent) images would be inversely related to aggressive behavior. Finally, we predicted that these effects would remain when individual differences in aggressiveness were statistically controlled.

Method

Participants

Thirty-nine healthy, male undergraduates (mean age = 19.5), all right-handed with normal or corrected-to-normal vision, volunteered in exchange for course credit. Participants were recruited using an internet-based experiment sign-up procedure advertising a study on "the effects of picture viewing on reaction times."

Measures

Video game violence exposure

As in previous research (Anderson & Dill, 2000; Bartholow, Sestir, & Davis, in press), participants completed a questionnaire in which they listed their five favorite video games and then rated each game, on scales anchored at 1 and 7, in terms of how often they play the game and the violence of the game's content and graphics. For each game, we multiplied the sum of the violent content and violent graphics ratings by the "how-often" rating. These five scores were averaged to form an overall index of video game violence exposure ($\alpha = .82$). For descriptive purposes, we refer to individuals with relatively high scores on this measure as violent video game players, and those who received relatively low scores as nonviolent video game players. However, participants were not dichotomized into these categories for analyses.

Trait aggressiveness

Individual differences in aggressiveness were assessed using the Irritability Scale (30 items; $\alpha = .87$; Caprara et al., 1985) and the Aggression Questionnaire (29 items; $\alpha = .88$; Buss & Perry, 1992). The Irritability Scale contains items such as, "I easily fly off the handle with those who don't listen or understand." Responses were made on scales anchored at 1 (*This doesn't characterize me at all*) and 5 (*This characterizes me very well*). The Aggression Questionnaire (AQ) contains 4 subscales, labeled Physical Aggression (9 items; $\alpha = .78$; e.g., "If somebody hits me, I hit back"); Verbal Aggression (5 items; $\alpha = .85$; e.g., "I can't help getting into arguments when people disagree with me"); Anger (7 items; $\alpha = .84$; e.g., "Some of my friends think I'm a hot-head"); and Hostility (8 items; $\alpha = .77$; e.g., "At times I feel I have gotten a raw deal out of life"). Responses were made on scales anchored at 1 (*Extremely uncharacteristic of me*) and 6 (*Extremely characteristic of me*). High scores on these measures are considered reliable and valid self-report indices of trait aggressiveness (e.g., Bushman & Wells, 1998; Caprara et al., 1985; Harris, 1996).

Aggressive behavior

Participants were led to believe that they were competing against another participant (the ostensible partner) in a reaction time task to see who could press a button faster following an auditory tone. They were further told that the slower person on a given trial would receive a blast of noise through a pair of headphones, the intensity and duration of which were set by the other person prior to that trial. At the end of each trial, the participant saw a message stating either "YOU WON!" or "YOU LOST!" and received a noise blast on losing trials. Noise intensities ranged from 60 decibels (level 1) to 105 decibels (level 10). A nonaggressive no-noise setting (level 0) was also offered. In addition to setting the intensity, the winner also determined the duration of the loser's suffering using a noise duration setting ranging from 0.25 s (level 1) to 2.5 s (level 10). In effect, each participant controlled a weapon that could be used to blast the other person with loud noise on winning trials. Aggression was defined as the average intensity and duration of noise (standardized and summed) that the participant set for the ostensible partner over the 25 trials of the task.

Actually, there was no partner—the computer controlled trial wins and losses as well as noise intensities and durations ostensibly set by the partner. The participant lost the first trial, and half of the remaining 24 trials in a random pattern, with intensity levels varying randomly between levels 2 and 9. Duration levels varied randomly between 0.5 and 2.0 s. Previous research has established the validity and reliability of this widely used aggression measure (e.g., Bernstein, Richardson, & Hammock, 1987; Giancola & Zeichner, 1995), and we have used it successfully in many of our previous studies (e.g., Bartholow & Anderson, 2002; Bartholow et al., in press; Bushman, 1995).

Electrophysiological recording

The EEG was recorded from 28 electrodes fixed in an electrode cap (Electro-cap International, Eaton, OH) at standard scalp locations. All EEG electrodes were referenced online to the right mastoid (an average mastoid reference was derived offline). EEG was continuously recorded and stimulus-locked ERP epochs of 1400 ms were derived offline (referenced to 200 ms pre-stimulus baseline). EEG was amplified with a Neuroscan Synamps amplifier and filtered on-line at 0.05–30 Hz at a sampling rate of 250 Hz. Impedance was kept below 5 kΩ. Ocular artifacts (blinks) were removed from the EEG using a regression-based procedure (Semlitsch, Anderer, Schuster, & Presslich, 1986). Trials containing voltage deflections of ±75 microvolts (μV) after ocular artifact removal were rejected prior to averaging. Off-line averages were derived according to participant, electrode, and stimulus conditions, and low-pass filtered at 12 Hz (12 dB roll-off).[1] Initial inspection of the waveforms confirmed that the P300 was largest at the midline parietal (Pz) electrode site. Therefore, for each participant, the P300 was identified by selecting the largest positive peak between 300 and 800 ms post-stimulus at Pz.[2] P300 amplitude was computed by averaging over the 300 ms around that peak (i.e., 150 ms before and after) in each condition.

Picture viewing task

All images used in this study were taken from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2001). Lang et al. (2001) had participants rate the valence of each image using scales ranging from 1 (*completely unhappy*) to 9 (*completely happy*) and their arousal to each image using scales ranging from 1 (*completely calm*) to 9 (*completely aroused*). Valence and arousal ratings for the images used in this study are presented in Table 1. Examples of the neutral images included pictures of a man on a bicycle; a man opening a backpack on a street corner; a towel laying on a table; and a mushroom. Example violent images included a man holding a gun to another man's head on a subway; a man holding a gun in another man's

[1] Applying a low-pass filter to the relatively low frequency activity embodied by the P300 is important in order to reduce the influence of higher frequencies, particularly when peak amplitude measures are used (e.g., Fabiani, Gratton, Karis, & Donchin, 1987).

[2] EEG data were recorded from the additional scalp locations for exploratory analyses not relevant to the psychological hypotheses being tested in this study. Therefore, we do not present those analyses here. It is worth noting, however, that the effects of video game violence exposure and image type were similar at all midline electrodes.

Table 1
Average valence and arousal ratings for the IAPS images used in this study

Image type	Valence ratings	Arousal ratings
Neutral	5.13 (0.66)	2.70 (0.66)
Violent	2.39 (0.17)	6.75 (0.22)
Negative nonviolent	2.26 (0.43)	6.09 (0.39)

Note. IAPS, International Affective Picture System. Numbers in parentheses are standard deviations. The identification numbers (from the IAPS manual; Lang et al., 2001) for the neutral images were 5875, 7493, 2749, 5410, 2840, 2850, 2870, 2880, 8465, 9210, 5500, 7000, 7002, 7009, 7010, 7025, 7030, 7035, 7040, 7080, 7090, 7140, 7217, 7224, and 7050. The violent images were numbered 3500, 3530, 6313, 6350, and 6540, and the nonviolent negative images were numbered 3170, 6415, 9570, 9800, and 9910.

mouth on a bus; and a man holding a knife to a woman's throat. Example negative nonviolent images included a baby with a large tumor on her face; a neo-Nazi skinhead in front of a swastika flag; and a decaying dog corpse.

As can be seen in Table 1, valence ratings for violent and negative nonviolent images were very similar ($d = 0.43$). However, the Lang et al. sample rated the violent images as more arousing than the negative nonviolent images ($d = 2.16$). Although the statistical significance of the mean differences presented in Table 1 cannot be calculated without Lang et al.'s data set, power analyses based on the effect sizes just noted showed that a sample size of approximately 200 would be required to detect a significant difference between the valence ratings 80 percent of the time with $\alpha = .05$ (two-tailed). In contrast, a significant difference between the arousal ratings would be detected 80% of the time using a sample size of only 10 (see Cohen, 1988).

Images were presented in 2 blocks of 48 trials each. In each block, target images were either neutral and negative or neutral and violent (half of the target images in each block were neutral). Block order was varied randomly across participants. Each trial consisted of 4 context images (always neutral), and 1 target image presented randomly in position 3, 4, or 5; thus, participants viewed a total of 480 images. Images were displayed for 1 s each, separated by a 1 s inter-stimulus interval. Participants were instructed to think about their reactions to each image. Trials were separated by a 2.5 s inter-trial interval, during which the word "ready" was displayed on the monitor. A short break (approximately 2 min) was inserted between blocks.

Procedure

After obtaining informed consent, the researcher applied all electrodes and explained the experimental tasks. Participants were told that the purpose of the study was to examine how viewing different kinds of images would affect response speed in an unrelated, competitive task. The researcher then left the room for several minutes, allegedly to explain the tasks to the other participant. Upon his return, the participant started the picture viewing task. After completing the picture viewing task, the participant waited 3 min while the experimenter allegedly set up the second task on the other participant's computer. The experimenter then returned again and read the instructions for the competitive task, after which the participant completed the task. Finally, participants were interviewed for suspicion, debriefed, and dismissed.

Results

Data from 5 participants were discarded (2 had a high proportion of EEG artifacts and 3 were suspicious that they were not competing against anyone during the competitive task). Thus, all analyses were based on data from 34 participants.

Simple bivariate associations among the main study variables are given in Table 2. Consistent with previous research (Anderson & Dill, 2000; Bartholow et al., in press), video game violence exposure was strongly associated with

Table 2
Bivariate associations among the main study variables

	1	2	3	4	5	6	7	8	9
1. VVE	—								
2. Aggression	$.57^{***}$	—							
3. Violent P300	$-.64^{***}$	$-.48^{**}$	—						
4. Negative P300	.00	−.20	$.34^{*}$	—					
5. Neutral P300	.17	.04	.05	$.43^{**}$	—				
6. Irritability	−.14	$.26^{\dagger}$	$-.34^{*}$	−.17	−.07	—			
7. AQ-H	.05	.24	$-.31^{*}$	−.15	−.18	$.56^{***}$	—		
8. AQ-A	−.23	−.17	−.14	−.24	−.09	$.70^{***}$	$.58^{***}$	—	
9. AQ-P	.04	.12	$-.38^{*}$	−.22	.09	$.65^{***}$	$.58^{***}$	$.52^{***}$	—
10. AQ-V	.21	.10	−.11	−.18	.03	$.32^{*}$	.23	$.33^{*}$	$.30^{\dagger}$

Note. VVE, video game violence exposure; Aggression, composite aggression score from competitive task; Irritability, Irritability Scale scores; AQ-H, Aggression Questionnaire hostility subscale; AQ-A, Aggression Questionnaire anger subscale; AQ-P, Aggression Questionnaire physical aggression subscale; AQ-V, Aggression Questionnaire verbal aggression subscale.

* $p < .05$.
** $p < .01$.
*** $p < .001$.
† $p < .10$.

increased aggression during the competitive reaction time task. More pertinent to our current hypotheses, violent video game exposure was inversely associated with the amplitude of the P300 elicited by violent images during the picture viewing task, which was inversely associated with aggressive behavior. However, our hypotheses are more appropriately tested by the analyses presented next in which the effects of violent video game exposure on all image types is compared and in which individual differences in aggressiveness are controlled.

Our first major prediction was that P300 amplitudes to violent images would be smaller for violent game players than for nonviolent game players, and that this effect would not generalize to other negative images. A general linear model showed that the predicted interaction between the 3-level image type variable (neutral, negative, violent) and video game violence exposure scores (continuous variable) was significant, $F(2,64) = 12.03$, $p < .0001$ (Greenhouse-Geisser adjusted; $\varepsilon = .99$). Separate regression analyses within each image type showed that, as expected, P300 amplitudes to violent images decreased as a function of increased violent video game exposure, $t(32) = -4.66$, $p < .0001$, $b = -.20$ (see Fig. 1A). However, P300 amplitudes to neutral images were not affected by violent video game exposure, $t(32) = 1.00$, $p = .33$, $b = .03$, nor were P300 amplitudes to negative nonviolent images, $t(32) = 0.02$, $p = .98$, $b = .00$ (see Fig. 1B). This latter finding rules out the possibility that evaluative categorization of all negative stimuli is blunted in violent game players, relative to nonviolent game players, supporting the idea that violent game players are specifically desensitized to violence.

The analysis just presented examined brain responses to violent, negative, and neutral images in an absolute sense. Another, perhaps more focused way of conceptualizing desensitization is in terms of the degree to which responses to violent images are attenuated relative to responses to equally negative nonviolent images. To test this possibility, we computed a new variable for each participant representing the difference between their P300 responses to negative images and violent images and examined the association between this difference score and video game violence exposure. This association was positive, $t(32) = 3.73$, $p < .001$, $b = .20$, $\beta = .55$, indicating that increased exposure to video game violence was associated with a larger difference between the P300 response to negative images and violent images, which can be seen by comparing panels A and B of Fig. 1.

It is possible that the effect of video game violence exposure on P300 amplitudes to violent stimuli is due to individual differences in aggressiveness. To examine this alternative explanation of our effects, we tested the association between P300 amplitudes elicited by violent images and violent video game exposure while simultaneously covarying Irritability scores and scores on each AQ subscale. The effect of video game violence exposure on P300 amplitudes to violent images remained significant in this analysis, $t(27) = -5.55$, $p < .0001$, $b = -.22$, $\beta = -.71$, despite

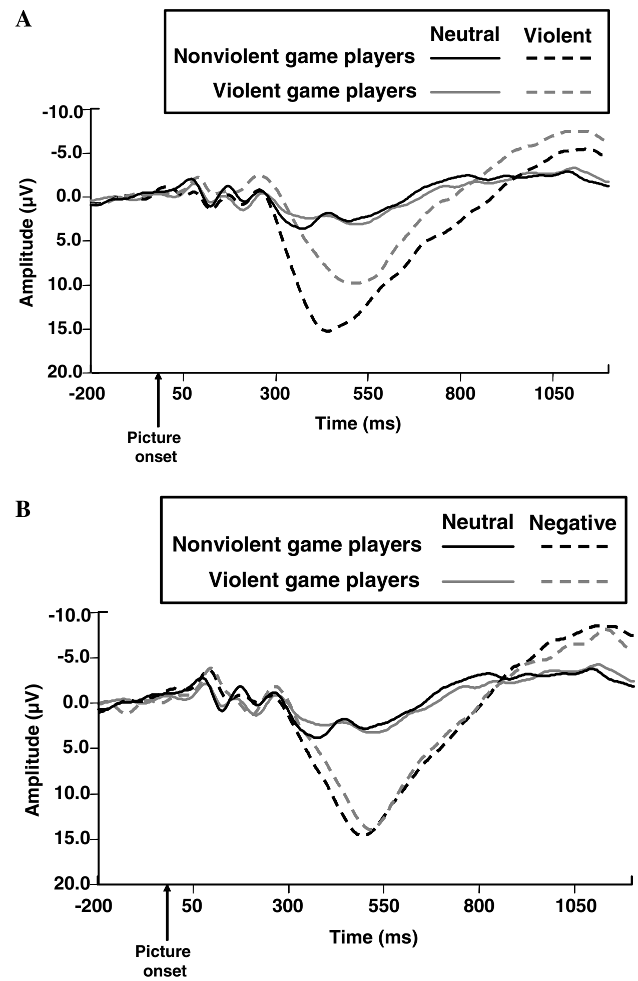

Fig. 1. Event-related potential waveforms measured at the Pz (midline parietal) electrode site as a function of picture type and levels of prior exposure to video game violence. For purposes of presentation, participants were categorized as either violent (gray lines) or nonviolent (black lines) video game players using a median split (though the continuous measure was used in all analyses). (A) The P300 elicited by neutral images (solid lines) and violent images (dashed lines). (B) The P300 elicited by neutral images (solid lines) and negative nonviolent images (dashed lines).

the fact that Irritability scores also accounted for significant variance in P300 amplitudes to violent images, $t(27) = -2.03$, $p < .05$, $b = -2.00$, $\beta = -.37$. None of the AQ subscales accounted for significant variance in P300 amplitude to violent stimuli (βs ranged from $-.25$ to $.27$; ps $> .05$).

Inspection of Fig. 1A suggests that in addition to the amplitude difference reported previously, the peak latency of the P300 elicited by violent images also appears to be affected by video game violence exposure. A general linear model confirmed that the P300 to violent images peaked later among violent video game players than among nonviolent video game players, $t(32) = 2.19$, $p < .05$, $b = 8.18$, $\beta = .36$. This effect was not weakened by the inclusion of Irritability Scale scores and AQ subscale scores, $t(27) = 2.68$, $p < .05$, $b = 9.75$, $\beta = .45$; the AQ-anger subscale was the only other significant predictor in this model, $t(27) = 2.66$, $p < .05$, $b = 7.20$, $\beta = .56$. A separate general linear model indicated that, in contrast, P300 latency elicited by nonviolent negative images was not affected by violent video game exposure, $t(32) = -.03$, $p > .90$, $b = -.02$, $\beta = -.01$ (see Fig. 1B).

Our second major prediction was that the P300 elicited by violent images would significantly predict aggressive behavior in the competitive reaction time task. A regression analysis showed the predicted inverse relationship: smaller P300 amplitudes to violent images (seen primarily among violent video game players) during the picture viewing task were significantly associated with higher levels of aggression, $t(32) = -3.11$, $p < .01$, $b = -.46$, $r = -.48$ (see Fig. 2A). In contrast, P300 amplitudes elicited by negative nonviolent images were not significantly associated with aggression, $t(32) = -1.16$, $p = .25$, $b = -.19$, $r = -.20$. Finally, a separate regression analysis showed that the more time participants spent playing violent video games, the more they aggressed against their ostensible partner, $t(32) = 3.88$, $p < .001$, $b = .17$, $r = .57$ (see Fig. 2B). This relationship also held after controlling for individual differences in aggressiveness, $t(32) = 3.68$, $p < .001$, $b = .16$, $\beta = .57$.

We also examined the association between the P300 difference score variable (negative images-violent images) mentioned previously and aggressive behavior during the competitive task. This association was positive, $t(32) = 2.12$, $p < .05$, $b = .29$, $\beta = .35$, indicating that a larger difference in the P300 elicited by negative images relative to violent images was associated with increased aggression.

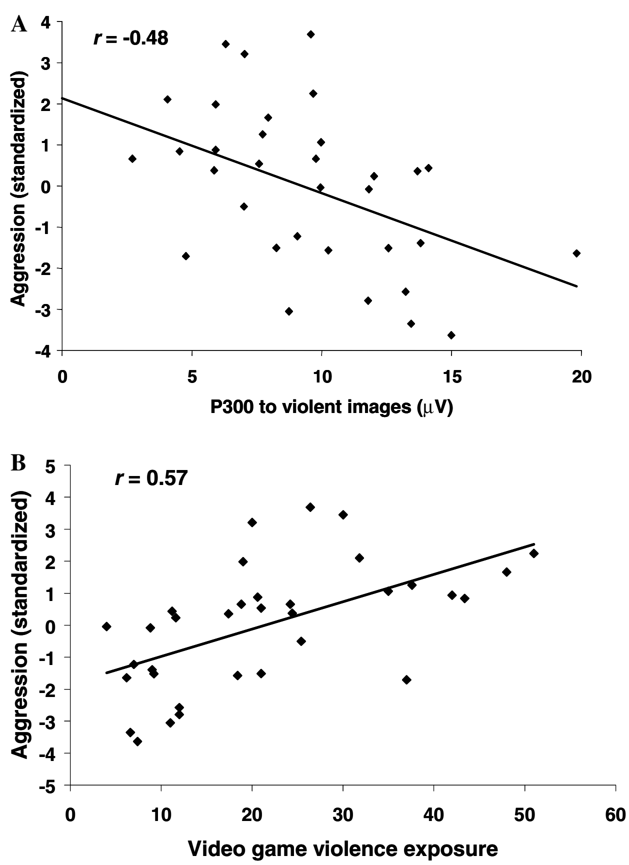

Fig. 2. Scatterplots depicting the magnitude of association between aggressive behavior (i.e., intensity and duration of noise blasts given to the ostensible partner during the competitive reaction time task) and the amplitude of the P300 elicited by violent images during the picture viewing task (A), and scores on the video game violence exposure measure (B).

Our contention is that exposure to violent video games leads to desensitization, as evidenced by reduced cortical responses to violent images and increased aggressive behavior. However, because the video game violence exposure measure used here combines the frequency of game play with the violence of game content, it is possible that the effects just reported are due to a more general phenomenon associated with frequently playing any video games, not violent games per se. To examine this possibility, we broke the video game violence exposure score into constituent average game content and gaming frequency scores for each participant, and examined their respective influences on the main dependent variables. Game content and overall frequency of game play were only modestly correlated, $r = .30$, $p = .06$, suggesting considerable independence in these dimensions. A regression equation in which both the content and frequency scores were used to simultaneously predict P300 amplitudes elicited by violent images showed that violent content was a strong predictor of reduced P300 amplitude, $t(31) = -3.90$, $p < .001$, $b = -1.73$, $\beta = -.54$, but gaming frequency was much less strongly associated, $t(31) = -1.90$, $p = .06$, $b = -0.93$, $\beta = -.27$. A similar regression equation showed that whereas violent content was a unique predictor of aggressive behavior during the competitive task, $t(31) = 2.66$, $p < .05$, $b = 1.27$, $\beta = .42$, frequency of play was not, $t(31) = 1.67$, $p > .10$, $b = 0.86$, $\beta = .25$. Thus, although there is some evidence that the frequency of video game play has an independent effect on the cognitive processing of violent images, these analyses largely support the conclusion that exposure to violent games specifically (and not just any games) is responsible for our reported effects.

Discussion

Previous research has shown that playing violent video games increases aggressive behavior and decreases helping behavior (see Anderson, 2004; Anderson & Bushman, 2001). One possible explanation for these effects is that people become desensitized to violence after prolonged exposure to it, leading to reduction of normal inhibitions against aggression and making individuals less responsive to the pain and suffering experienced by victims of violence (Carnagey, Bushman, & Anderson, 2005; Funk et al., 2004). The present research advances this desensitization account by showing that repeated exposure to violent video games is reflected in the brain as blunted evaluative categorization of violent stimuli. Compared to nonviolent video game players, violent video game players showed reduced P300 amplitude and increased P300 latency to violent images but not to other, equally negative nonviolent images. The latency of the P300 component generally is associated with stimulus evaluation or categorization time (see

Fabiani et al., 2000). Thus, the increased latency among violent video game players indicates that it took these individuals longer to categorize the violent images. The fact that the ERP findings held even after controlling for individual differences in aggressiveness is inconsistent with some alternative accounts suggesting that media violence effects are spurious (e.g., Freedman, 2002).

Moreover, P300 amplitudes elicited by violent images during the picture-viewing task were inversely associated with aggression during the competitive reaction time task. This finding is consistent with work showing that aggressive individuals tend to show deficits in P300 amplitude during simple stimulus discrimination tasks (Harmon-Jones, Barratt, & Wigg, 1997; Mathias & Stanford, 1999). However, this finding is inconsistent with the notion, advanced by some, that the effects of video game violence exposure on aggression are short-lived and have no long-term consequences for gamers (e.g., Freedman, 1984). More generally, these findings are the first to link violent video game exposure to a reduction in brain activity known to reflect activation of the aversive motivational system (see Ito et al., 1998b), and to link this brain activity to aggressive behavior. Nevertheless, it will be important to replicate these findings using a longitudinal design in which participants can be randomly assigned to violent and nonviolent media exposure conditions.

As discussed previously, although the violent and negative images used here were rated as equally unpleasant by participants in the norming sample, the violent images were more arousing on average than the negative nonviolent images (see Table 1). Other researchers have argued that self-reported arousal ratings of IAPS images reflect the degree of activation of the aversive motivational system (Ito, Cacioppo, & Lang, 1998a). The fact that violent video game players showed reduced cortical responses to violent images, but not to other negative images, is consistent with prior research and theory indicating that desensitization limits emotional arousal to violent stimuli (see Smith & Donnerstein, 1998), and suggests that this decreased arousal signifies a relaxation of avoidant motivational processes specifically associated with violence.

These findings pertaining to arousal could have important implications for linking violence desensitization to aggressive behavioral disorders. Antisocial personality disorder is typified by low arousal in the aversive motivational system (e.g., Fowles, 1988) and is a significant risk factor for aggressive and violent behavior (e.g., Langbehn, Cadoret, Yates, Troughton, & Stewart, 1998). Recently, Herpertz et al. (2005) reported that adolescent boys with conduct disorder show abnormally low autonomic responses to valenced images like those used in the current study (although those researchers combined responses to violent and other negative images). Some evidence suggests that symptoms associated with antisocial personality disorder (e.g., delinquency) are positively correlated with exposure to video game violence (Anderson & Dill, 2000). Thus, although the current findings were not dependent upon individual differences in self-reported aggressiveness, it would be of interest in future research to examine potential links between P300 responses to violent images, aggressive behavior, and antisocial personality disorder.

As noted previously, the P300 is known to be associated with working memory updating (Donchin & Coles, 1988), considered by some to be a key component of so-called executive cognitive function (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). Recent brain imaging data indicate that adolescents high in media violence exposure show abnormal frontal lobe function during the performance of executive tasks (Mathews et al., 2005), a finding consistent with other work showing executive dysfunction among violent video game players (Kronenberger et al., 2005). As in the current study, these effects were not attributable to differences in trait aggression in either of these other reports, although Mathews et al. (2005) reported that the pattern of brain activation seen in their violent media exposed participants resembled that of a separate group of participants diagnosed with disruptive behavioral disorder. The current research extends this recent work by examining a different neural index of executive dysfunction associated with processing violence, and by showing links between this brain activity and aggressive behavior measured in the lab.

One important limitation of the current findings deserves mention. Although our hypotheses (and indeed, our findings) suggest a potential mediational role for P300 amplitude in the link between video game violence exposure and aggressive behavior, specific tests for mediation did not support this idea. Thus, although these three variables are clearly significantly associated, the brain response to violent images did not account for the effect of violence exposure on aggression in this study. It will be important in future research to identify potential mediators of this effect.

In summary, this study is the first to link video game violence exposure and aggressive behavior to brain processes hypothetically reflecting desensitization in the aversive motivational system. These findings, along with other recent research (Kronenberger et al., 2005; Mathews et al., 2005), suggest that chronic exposure to violent video games specifically—and not just frequent playing of any video games—has lasting deleterious effects on brain function and behavior.

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