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Relationship between Video Game Violence and Long-Term Neuropsychological Outcomes

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Abstract

The current study examined the long-term effects of video game violence on aggressiveness and facial expression recognition using multiple measures. In Experiment 1, participants unfamiliar with video games were randomly assigned to play a violent or nonviolent video game for four weeks. Before and after the game play interval, event-related potentials (ERP) evoked by facial expressions were recorded, and aggressiveness was measured with a questionnaire. Results showed that playing a violent video game delayed peak latency of a positive component of the ERP evoked by angry faces and increased aggressiveness among male participants. Experiment 2 included a 3-month follow-up assessment. Results showed preservation of delayed neural activity, while levels of aggressiveness diminished to some extent. These findings highlight differential aspects regarding the long-term effects of playing a violent video game: more enduring for facial expression recognition and short-lived for aggressiveness.

Keywords

Violent Media, Facial Expression Recognition, Aggression, Event-Related Potential (ERP)

1. Introduction

Several studies have assessed the negative effects of exposure to media violence (see Anderson et al., 2003). As video games have become more popular, various studies have examined the negative effects of exposure to video game violence (see Anderson et al., 2010). Past research has shown that exposure to game violence is linked to increased levels of aggression (Anderson & Dill, 2000), hostile expectations (Bushman & Anderson, 2002), and lower empathy (Funk, Baldacci, Pasold, & Baumgardner, 2004). Some studies have also examined the in-

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fluence of exposure to game violence and perceptual facial expression processing (Kirsh & Mounts, 2007; Kirsh, Mounts, & Olczak, 2006). Results have indicated that playing violent video games induces negative processing biases when recognizing facial emotion.

Despite the aforementioned evidence, two important questions remain. First, most studies have focused on the short-term effects of violent video game exposure (Devilly, Callahan, & Armitage, 2012). In such studies, participants are asked to play violent video games over a brief interval (e.g., only a few minutes to an hour). Though some studies have examined extended exposure to violent video games (e.g., three days), the total time spent playing is modest (e.g., 1 total hour over 3 days; Hasan, Bègue, Scharkow, & Bushman, 2012). Most video gamers play for more than a few hours at a time, maybe even more than 100 hours for any specific game, especially popular video games containing violence (e.g., Call of Duty or the Grand Theft Auto series). Thus, merely a few minutes of play are not sufficient to examine the actual effects of exposure to these video games. Though some correlational research has examined longitudinal effects of playing violent video games (Anderson et al., 2008; Ihori, Sakamoto, Kobayashi, & Kimura, 2003; Wallenius & Punamäki, 2008), no experimental study has investigated the long-term effects of violent video games. Given that digital devices, such as smart phones and tablet PCs, allow individuals to play video games anytime and anywhere, it is important to further address questions as to whether long-term exposure to violent video games leads to substantial negative outcomes.

Second, to more clearly understand the effects of exposure to game violence, cognitive neuroscientific methods should be included to examine how exposure to video game violence affects neural processes. This is because higher-order cognitive processes regarding the interpretation and assessment of video game violence on negative outcomes have generally been measured via questionnaires. This likely masks the actual effects of video game violence on psychological processes (Staude-Müller, Bliesener, & Luthman, 2008). As Lang (2006) pointed out, it is important to examine both how people process media messages and how the media affects information processing. For instance, one functional magnetic resonance imaging (fMRI) study showed that playing a violent video game suppresses limbic neural structures associated with emotional information processing (Weber, Ritterfield, & Mathiak, 2006). Previous studies using event-related brain potentials (ERP) have provided additional evidence suggesting that repeated exposure to media violence is linked to a desensitization to violence (Bailey, West, & Anderson, 2011; Bartholow, Bushman, & Sestir, 2006), and this desensitization mediates the effect of video game content on subsequent aggressive behavior (Engelhard, Bartholow, Kerr, & Bushman, 2011). There is also evidence indicating that video game violence induces physiological desensitization to violence, indexed by changes in heart rate and galvanic skin responses (Carnage, Anderson, & Bushman, 2007). However, no experimental study to date has explored the long-term effects of exposure to media violence on the neural processing of facial expressions. Thus, the present study examined the effects of early ERP components on the visual domain, the occipitotemporal N170, and P2. The N170 is a large posterior negative deflection that follows the visual presentation of a facial picture, peaking at occipitotemporal sites at around 170 ms (Bentin, Allison, Puce, Perez, & McCarthy, 1996). A number of fMRI studies have shown that the source of the N170 is centered on the fusiform gyrus and superior temporal gyrus (Horovitz, Rossion, Skudlarski, & Gore, 2004). One previous study observed a positive potential with a mean peak latency at around 220 ms, P2, which is associated with deeper processing of visual stimuli (Latinus & Taylor, 2005) and is not directly associated with facial expression categorization (Tamamiya & Hiraki, 2013). If playing violent video games affects the perceptual processing of facial expressions, the amplitudes or latencies of the N170 and P2 evoked by facial expressions should change after playing violent video games.

Recent studies have shown that video game training enhances many aspects of cognitive control (Green, Li, & Bavelier, 2010). Moreover, these enhancements are associated with neuroplasticity (Anguera et al., 2013; Kühn et al., 2014). Given this evidence, it seems beneficial to assess the long-term effects of exposure to video game violence, specifically on a neuropsychological level.

The aim of the current study was to examine whether the long-term exposure to video game violence would affect facial expression recognition and aggressiveness, and if so, how long the effects of video game violence would last after the game play ceased.

2. Experiment 1

2.1. Method: Participants

Participants were recruited from local Japanese universities. Twenty-two healthy, right-handed Japanese volunteers (10 females and 12 males, aged 18 - 29 years, mean age = 21.2, *SD* = 3.44) participated in the experiment. Participants were paid approximately 8000 yen. No participants had experience playing the video games used in the current study. Written informed consent was obtained from each participant before the experiment. The ethics committee of The University of Tokyo approved this study.

2.2. Video Games

All video games were played on PSP (PlayStation Portable), which allowed participants to play a video game at their convenience. The violent video game used in this study was "Grand Theft Auto: Liberty City Stories for PlayStation Portable" (GTA), and the nonviolent video game was "Boku no Natsuyasumi Portable: Mushi Mushi Hakase to Teppen-yama no Himitsu" (BOKUNATSU). GTA is an action-adventure video game. Players take on the role of a criminal who can roam freely around a big city. Various missions are set for completion such as bank robberies, assassinations, and other crimes. GTA contains frequent violent acts and scenes. BOKUNATSU is also an action-adventure video game. The player becomes a young boy who stays in the countryside during his summer vacation. The player can enjoy fishing, insect collecting, and talking with other characters. There is no violence in BOKUNATSU.

2.3. Questionnaire

Based on previous studies (Anderson & Dill, 2000; Bartholow, Bushman, & Sestir, 2006), a video game questionnaire was constructed. Participants were asked to list their five favorite video games and then rated each game on scales anchored from 1 to 7 in terms of how often they played each game and the violence portrayed in the game's content and graphics. Responses of 1 were labeled rarely no violent respectively. Responses of 7 were labeled often, extremely violent, respectively. For each participant, summing the violence content and violent graphics ratings, and multiplying this by the "how-often" rating, produced a violence exposure score for each participant's five favorite games. These five scores were averaged to form an overall index of video game violence exposure. The other focused on the amount of time spent playing each game, in general, computed by multiplying frequency, anchored at 1 (not at all) to 7 (everyday), by duration, anchored at 1 (1 to 15 minutes) to 7 (more than 3 hours). The range for general time spent playing a game was from 1 to 49 for each participant. Individual differences in aggressiveness were assessed using the Japanese version of the Buss-Perry Aggression Questionnaire (BAQ: Ando et al., 1999). The Japanese version of the BAQ includes 4 subscales: Physical Aggression (9 items; e.g., "If somebody hits me, I hit back"); Verbal Aggression (5 items; e.g., "My friends say that I'm somewhat argumentative"); Anger (7 items; e.g., "I have trouble controlling my temper"); and Hostility (8 items; e.g., "I am suspicious of overly friendly strangers"). Participants responded on scales anchored at 1 (This doesn't characterize me at all) to 5 (this characterizes me very well). Participants also rated an assigned video game on its level of violence, difficulty, fun, and action using 5-point scales ranging from 1 (strongly disagree) to 5 (strongly agree).

2.4. Stimuli and Task

Stimuli consisted of 10 photographs of facial expressions (a female and male posing angry, fearful, happy, sad, and neutral expressions) taken from the ATR Facial Expression Image Database (DB99). All stimuli were grayscale pictures. The protocol consisted of four blocks. Each block contained 120 facial stimuli, 24 for each expression and 6 target stimuli (a star). All photographs were 5.5 × 8 cm. The mean luminance was equal across stimuli. Stimuli were presented on a black background on a 17" CRT computer screen (EIZO FlexScan F520) at a viewing distance of 80 cm in front of the participants for 500 ms with an ISI of 1100 ms (see **Figure 1**). Participants were told that they would be shown a series of photographs and were asked to respond with a mouse click to the target stimulus (a star). The task was used to ensure that participants attended to the stimuli.

2.5. Electrophysiological Recording and Analysis

An electroencephalogram (EEG) was used to record ERP data from 65 electrodes with a Geodesic Sensor Net (Tucker et al., 1993) sampled at 250 Hz with a 1- to 100-Hz band-pass filter. Electrode impedance was below 100 kΩ. All recordings were initially referenced to the vertex and later digitally re-referenced to the averaged reference. In the off-line analysis, a 30-Hz low-pass filter was reapplied. All data were segmented into 500-ms

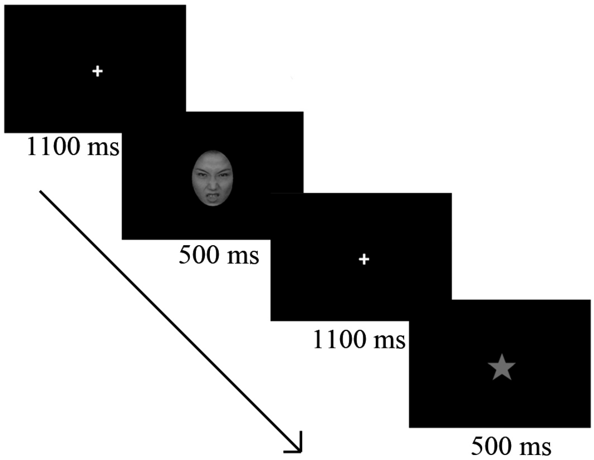

Figure 1. Time course of trials. Participants were instructed to respond only to a star.

epochs, including a 100-ms pre-stimulus baseline period, based on time markers for stimulus onset. Only segments less than 75 V in each channel were analyzed and baseline-corrected. Each component (N170, P2) was measured at the electrodes where the component was most prominent. N170 was measured at P7 and P8. P2 was measured at O1 and O2 (Latinus & Taylor, 2005; Tamamiya & Hiraki, 2013). Latencies were taken at the electrode where amplitude was maximal over each hemisphere, and amplitudes were measured at this latency.

2.6. Procedure

To examine the long-term effects of playing a violent video game, participants were assessed twice: before and after playing a video game. Each measurement time consisted of questionnaires and the EEG recording task. Thus, participants visited the laboratory a few times. After consent procedures were completed, baseline measurements were taken. Participants were randomly assigned to one of the two experimental conditions, and given a PSP with the assigned video game and told they would play the game for at least 4 hours a week, which would equate to 16 hours over the experimental period. After two weeks, participants were asked to visit the laboratory in order to demonstrate game progress. Within one week after playing the assigned video game for 16 hours, participants returned to the laboratory and completed the second measurements. Participants gave the assigned video game back to the researcher, and were asked not to play the game anymore.

2.7. Results: Video Game Violence Exposure and Amount of General Time Spent Playing

To compare participant's exposure to video game violence and amount of general time spent playing between the two conditions, a 2 × 2 (Video game [violent, nonviolent] × Gender [female, male]) analysis of variance (ANOVA) was conducted. None of the main effects or interactions reached significance ($ps > .05$). In other words, there were no significant differences in exposure to video game violence or amount of time spent playing the games at baseline. The average amount of time spent, in general, playing games was low ($M = 9.1$, the possible range of the scale is from 1 to 49), which indicated participants were not habitual game players as compared with a previous study (Carnagey et al., 2007).

2.8. Video Game Ratings

A 2 × 2 (Video game [violent, nonviolent] × Gender [female, male]) ANOVA was conducted. Ratings of game violence were affected by the type of game, $F(1, 16) = 235.64$, $p < .001$, $\eta_p^2 = .94$. The violent game was rated as more violent ($M = 4.8$, $SD = .42$) than the nonviolent game ($M = 1.2$, $SD = .63$), which indicates that the chosen games did in fact differ in violent content. Ratings of game difficulty were also affected by game type, $F(1, 16) = 38.72$, $p < .001$, $\eta_p^2 = .71$, and gender, $F(1, 16) = 5.12$, $p = .038$, $\eta_p^2 = .24$. The violent game was rated as more difficult ($M = 4.4$, $SD = .70$) than the nonviolent game ($M = 2.2$, $SD = 1.03$). Female participants rated the video games as more difficult ($M = 3.7$, $SD = 1.25$) than did male participants ($M = 2.9$, $SD = 1.52$). The video game × gender interaction was significant in terms of game enjoyment ratings, $F(1, 16) = 7.78$, $p = .013$, $\eta_p^2 = .33$. Female participants enjoyed the nonviolent game ($M = 4.8$, $SD = .45$) more than the violent game ($M = 3.0$, $SD = 1.23$). Participants rated both games as equally action-packed ($p > .05$). Given some of the significant effects of video game type in terms of difficulty and enjoyment, we used these variables as covariates in subsequent analyses. However, our main results were not affected by the addition of these covariates.

2.9. BAQ

Scores on the BAQ were analyzed using a 2 × 2 × 2 (Video game [violent, non-violent] × Gender [female, male] × Measurement time [baseline, after playing the video game]) ANOVA. Results yielded a significant video game × measurement time × gender interaction, $F(1, 18) = 4.64$, $p = .037$, $\eta_p^2 = .21$, on the Physical Aggression subscale (see **Figure 2**). This interaction revealed that male participants who played the violent game were more aggressive after playing the game (*Ms* = 14.5, and 16.8, *SDs* = 5.47 and 5.67). No other significant effects on the BAQ subscales emerged.

2.10. EEG

Amplitudes and latencies of the N170 and P2 ERP components evoked by emotional expressions were analyzed (see **Table 1**). There was no significant effect on amplitudes and latencies of the N170 and amplitudes of the P2 for any expressions, *Fs* < 3.90, *ps* > .05. For the P2 latency over the left hemisphere site evoked by angry faces, the video game × measurement time interaction was significant, $F(1, 18) = 5.43$, $p = .032$, $\eta_p^2 = .23$ (see **Figure 3** and **Figure 4**). The P2 latency of participants playing a violent video game was longer after playing the game than at baseline (*Ms* = 232 ms, and 242 ms, *SDs* = 17.42 and 15.63). There was no significant effect on the P2 latency for other expressions, *Fs* < 1.48, *ps* > .05.

To investigate the relationship between increased aggressiveness and the delayed P2 latency, the difference scores for both variables between baseline and after game play were computed, and the association was examined. There was no significant correlation between increased aggressiveness and the delayed P2 latency ($r = .189$, $p = .40$); thus, the effects of playing a violent video game on angry facial expression recognition and aggressiveness were independent, respectively.

2.11. Discussion

The present experiment demonstrated that playing a violent video game over a longer time interval affects not only reported aggressiveness among players but also neural signatures related to emotional facial recognition. We were next interested in the persistence of these effects. Experiment 2 was conducted as a follow-up to assess the lasting effects of video game violence exposure over a period of a few months.

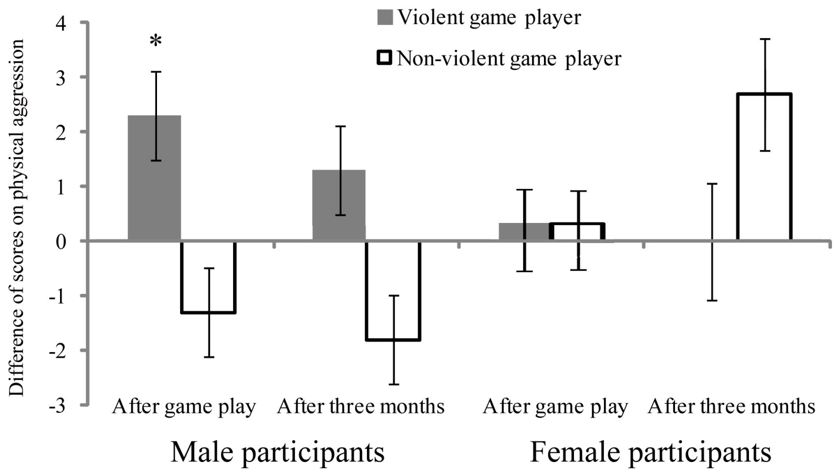

Figure 2. The effect of playing a video game on physical aggression. Each score was computed by subtracting aggression from baseline. A positive score indicates an increase in physical aggression from baseline. Error bars represent ±1 SE.

Table 1. Grand average amplitude and latency for the N170 and P2 responses to facial expressions.

	N170								P2							
	Amplitude (μV)				Latency (ms)				Amplitude (μV)				Latency (ms)			
	Left (P7)		Right (P8)		Left (P7)		Right (P8)		Left (O1)		Right (O2)		Left (O1)		Right (O2)	
	VVGP	NVGP	VVGP	NVGP	VVGP	NVGP	VVGP	NVGP	VVGP	NVGP	VVGP	NVGP	VVGP	NVGP	VVGP	NVGP
Angry1	−4.1 (0.7)	−3.4 (0.7)	−5.4 (0.8)	−4.0 (0.7)	181.8 (4.0)	184.0 (4.0)	177.5 (4.6)	185.5 (5.6)	1.9 (1.2)	3.2 (1.1)	2 (1.4)	2.6 (0.9)	231.6 (5.3)	242.2 (4.6)	234.9 (5)	248.7 (5.1)
Angry2	−4.2 (0.7)	−4.2 (0.8)	−4.8 (0.7)	−5.4 (1.0)	183.6 (4.1)	182.2 (4.3)	178.6 (5.0)	183.6 (6.5)	2.6 (1.3)	4.2 (1.2)	2.6 (1.1)	3.1 (1.1)	241.8 (4.7)	237.1 (3.0)	241.5 (6.2)	242.2 (2.7)
Angry3	−4.1 (0.8)	−3.7 (0.7)	−4.4 (0.8)	−4.8 (1.2)	181.8 (3.0)	175.6 (4.0)	176.4 (1.9)	171.6 (5.3)	3.2 (0.8)	2.9 (1.1)	3 (0.8)	2.7 (1.3)	244.4 (6)	236.9 (3.0)	248 (5.6)	237.8 (4.3)
Fearful1	−3.8 (0.7)	−3.1 (0.7)	−4.4 (0.7)	−3.9 (0.8)	181.8 (4.8)	181.8 (4.2)	176.0 (4.2)	180.7 (5.1)	3 (1)	4.2 (0.9)	2.8 (1.1)	3.6 (0.7)	236.7 (6)	235.3 (3.5)	236.7 (5.4)	236.4 (4.2)
Fearful2	−4.3 (0.8)	−3.9 (0.7)	−4.5 (0.6)	−4.6 (1.0)	180.4 (4.0)	185.1 (5.0)	176.4 (4.3)	181.1 (5.2)	2.4 (1.4)	4.0 (1.1)	2.4 (1.2)	3.2 (1.0)	238.6 (4.7)	244.7 (4.2)	236.4 (5.2)	240.0 (3.8)
Fearful3	−3.5 (0.9)	−3.5 (0.9)	−3.9 (0.8)	−4.4 (1.1)	176.0 (4.4)	174.7 (4.2)	171.1 (2.7)	168.9 (5.8)	2.7 (0.9)	3.0 (1.2)	3.3 (0.7)	3.3 (1.4)	239.1 (4.4)	237.8 (3.7)	243.1 (5.2)	242.7 (4.9)
Happy1	−3.9 (0.5)	−3.3 (0.6)	−4.5 (0.5)	−3.6 (0.6)	179.3 (4.4)	182.2 (4.5)	175.6 (4.4)	180.4 (5.3)	2.6 (1.2)	4.0 (0.9)	2.3 (1.2)	3.3 (0.8)	230.9 (4.1)	233.5 (4.4)	236.4 (4.9)	234.9 (3.7)
Happy2	−3.9 (0.8)	−3.7 (0.7)	−4.3 (0.6)	−4.5 (0.9)	179.3 (3.7)	179.3 (4.8)	175.6 (4.7)	178.6 (5.1)	3.4 (1.3)	4.6 (1.2)	2.6 (1.2)	3.7 (1.1)	233.1 (6.2)	233.8 (3.7)	236.4 (4.6)	236.0 (3.3)
Happy3	−3.8 (0.8)	−3.5 (0.9)	−3.7 (0.8)	−3.8 (1.1)	177.8 (3.4)	175.6 (4.1)	173.8 (2.1)	169.3 (5.7)	3.3 (1)	3.1 (1.2)	3.5 (0.8)	3.2 (1.4)	234.7 (4.9)	232.4 (4.2)	241.8 (3.5)	230.2 (3.5)
Neutral1	−3.5 (0.7)	−3.2 (0.5)	−4.4 (0.8)	−3.4 (0.6)	183.6 (4.2)	180.0 (4.5)	174.2 (4.2)	177.5 (4.8)	2.5 (1.1)	3.3 (0.8)	2.2 (1.2)	2.7 (0.8)	236.4 (3.7)	240.0 (4.8)	237.5 (4.5)	241.1 (4.6)
Neutral2	−4.2 (0.8)	−3.1 (0.6)	−4.5 (0.6)	−4.4 (1.0)	180.4 (4.1)	176.7 (4.2)	173.8 (4.2)	181.8 (6.7)	3 (1.2)	4.6 (1.2)	2.5 (1.1)	4.0 (1.2)	232.7 (4.1)	235.6 (3.0)	236.7 (4.1)	234.2 (3.9)
Neutral3	−3.4 (0.7)	−3.0 (1.0)	−4.1 (0.6)	−3.6 (1.0)	178.2 (4.0)	176.0 (4.5)	175.6 (2.7)	169.8 (5.6)	3.3 (1)	3.7 (1.2)	3.6 (0.8)	4.1 (1.4)	242.2 (4.7)	231.1 (2.9)	241.3 (5.2)	235.6 (2.7)
Sad1	−3.5 (0.6)	−3.3 (0.7)	−4.3 (0.6)	−3.6 (0.7)	183.6 (4.2)	181.1 (4.6)	176.7 (3.9)	180.0 (4.1)	3.1 (1.1)	3.5 (0.7)	2.5 (1.3)	2.9 (0.8)	230.6 (3.8)	237.8 (5.1)	229.8 (3.7)	239.3 (4.4)
Sad2	−4.1 (0.8)	−3.5 (0.8)	−4.0 (0.6)	−5.0 (0.9)	182.6 (3.7)	180.4 (5.9)	176.7 (4.3)	184.0 (4.9)	3.3 (1.3)	4.5 (1.1)	2.9 (1.2)	3.6 (1.0)	237.5 (6.2)	240.0 (2.6)	237.8 (5.4)	239.3 (4.1)
Sad3	−3.6 (1.0)	−3.5 (0.9)	−3.9 (0.6)	−3.9 (1.0)	174.2 (8.1)	175.1 (3.6)	179.1 (3.3)	169.8 (5.6)	2.7 (1)	2.9 (1.3)	3.1 (0.7)	2.9 (1.4)	235.6 (6.9)	232.0 (3.3)	240.9 (6.2)	237.8 (4.9)

Note: [ERPs elicited by facial expressions at each measurement time (e.g., Angry1 is baseline. Angry2 is after game play. Angry3 is after three months.) for violent video game players (VVGP) and nonviolent video game players (NVGP).]

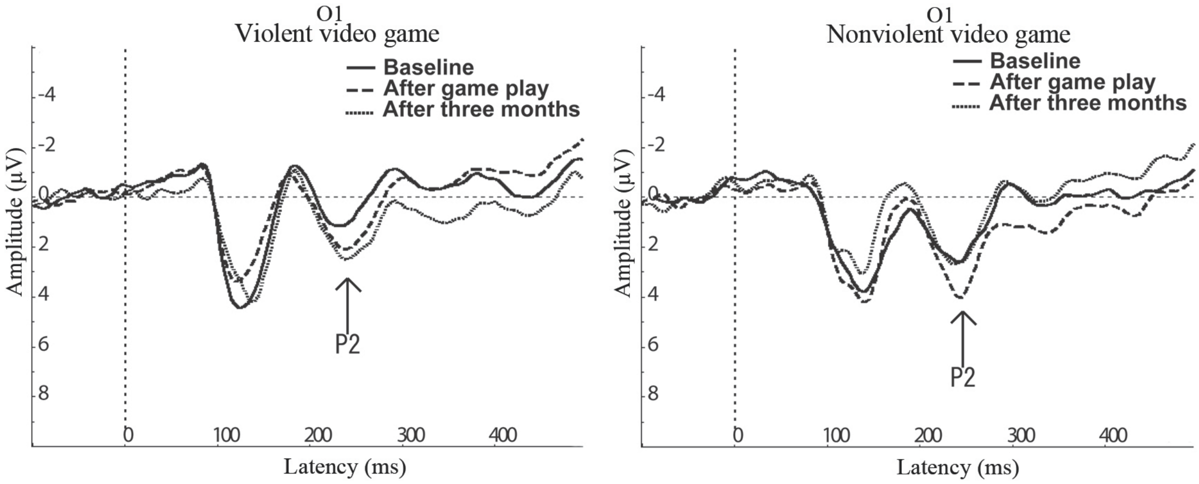

Figure 3. Grand average ERP waveforms evoked by angry faces. Electrode site O1 is displayed.

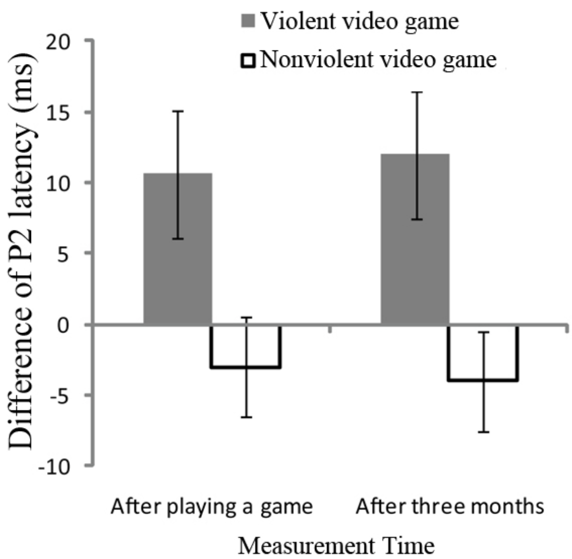

Figure 4. The effect of playing a video game on P2 latency evoked by angry faces. Each score was computed by subtracting from baseline. A positive score indicates a delay in the peak latency. Error bars represent ±1 SE.

3. Experiment 2

3.1. Method: Participants

Eighteen participants (6 females and 12 males) who participated in Experiment 1 participated in Experiment 2. Four participants were unable to return to complete their follow-up assessments. Participants were paid approximately 2000 yen.

3.2. Procedure

Three months after the second measurement, participants returned to the laboratory and completed a third assessment. The task and questionnaire were identical to Experiment 1. Participants were fully debriefed regarding Experiments 1 and 2 and dismissed.

To test whether the effects of a violent video game remained after three months, we compared the 3-month measurements with those at baseline and the measures obtained after the initial game play period.

3.3. Results: BAQ

No main effects or any interactions were significant (*ps* > .05). Though not significant, physical aggression that increased after playing the violent video game tended to decrease and revert back near baseline levels (*Ms* = 14.5, 16.8, and 15.8, *SDs* = 5.47, 5.67 and 6.34, respectively, see **Figure 2**).

3.4. EEG

Results showed no significant effect on the N170 after 3 months. As in Experiment 1, regarding the P2 latency evoked by angry faces, the video game × measurement time interaction was significant, $F(2, 28) = 5.92$, $p = .007$, $\eta_p^2 = .30$ (see **Figure 3** and **Figure 4**). This interaction indicated that the latency of the P2 evoked by angry faces among participants who played the violent video game maintained its delay even after 3 months (*Ms* = 231 ms, 242 ms, and 244 ms, *SDs* = 17.42, 15.63 and 18.05 respectively; see **Figure 4**).

4. General Discussion

The current study investigated the long-term effects of playing violent video games on facial expression recognition and aggressiveness. Previous research has shown that exposure to violent video games biases interpretations of emotional stimuli (Kirsh, Olczak, & Mounts, 2005; Kirsh & Mounts, 2007). The current study advances this literature by showing how playing a violent video game might affect neural activity associated with facial expression recognition. We observed that compared to nonviolent video game players, violent video game players showed delayed P2 latency evoked by angry faces. Meanwhile, no significant effects were found in the N170. Given that the N170 reflects categorization of facial expressions (Tamamiya & Hiraki, 2013), playing a violent video game might not affect any sort of categorization process. According to Sharma and McKenna (2001), several studies, using both clinical and nonclinical samples, have demonstrated that emotionally laden stimuli that correspond to the emotional state of the participant produce greater interference (i.e., longer response latencies) than neutral stimuli. For instance, after being insulted, participants show attention biases toward anger-relevant stimuli (Eckhardt & Cohen, 1997). In addition, a shift in latency for processing faces has been observed when participants are engaged in more analytic forms of facial decoding (Jemel, George, Chaby, Fiori, & Renault, 1999). Taken together, results of the present study indicate that playing violent video games, where players are typically insulted by an antagonist, causes attention biases toward anger-relevant stimuli, which results in delayed P2 latency. Thus, after extensive exposure with playing violent video games, players might analytically process negative facial expressions to a greater extent.

Considering that video game training can improve perceptual skills (Green et al., 2010), cognitive control (Anguera et al., 2013), and amblyopia (Jeon, Lewis, & Maurer, 2012), it is likely that playing a violent video game could modulate facial expression recognition. Moreover, observed effects on P2 latency were sustained even after a few months post playing the game. This maintenance is consistent with recent studies reporting that playing video games might induce neuroplasticity (Kühn et al., 2014), and this neuroplasticity might be preserved over long intervals (Anguera et al., 2013).

Previous studies demonstrated that playing violent video games for a few minutes immediately increases aggressiveness (Anderson & Dill, 2000; Bushman & Anderson, 2002). However, long-term effects of playing violent video games on aggressiveness have remained elusive. The current study observed that playing a violent video game increased physical aggressiveness even after just a few days playing the game. This finding is compatible with cross-lagged effect model analyses indicating that playing video games predicts later physical violence among players (Ihori et al., 2003). Some research suggests that playing a violent video game activates aggressive knowledge structures, which leads to increased aggressiveness (Barlett et al., 2009). When playing violent video games, players have to control characters that engage in physical behaviors (e.g., kicking and shooting antagonists). As a result, knowledge structures specifically related to physical aggression are most activated (Ihori et al., 2003).

We also observed a gender difference in the effects of playing a violent video game on aggressiveness. Previous studies have been unclear as to the consistency of gender effects. For example, Bartholow and Anderson (2005) suggested that males are more affected by violent video games than are females; while, other studies have not observed this trend (see, Bushman, & Anderson, 2002; Gentile, Lynch, Linder, & Walsh, 2004). Bartholow and Anderson (2005) argued that because males are more aggressive than females, in general, they are more sensitive to aggressive cues. Thus, the effect of playing violent video games on aggressiveness might be more pronounced for males than females. Another possible explanation of the observed gender difference could be related to the video games, themselves. It is known that identifying with violent video game characters makes players more aggressive (Konijn, Bijvank, & Bushman, 2007). The main character in the GTA game we chose is male. Thus, it might be easier for male participants to identify themselves with this violent character. This perhaps led to increased aggressiveness.

It is important to note that once game play ceased, the increased aggressiveness observed post-exposure to the violent video game tended to decrease toward participants' baseline. This finding is consistent with the notion that the effects of television violence exposure on aggression are relatively short-lived and might lack long-term consequences (e.g., Freedman, 1984). As discussed previously, playing a violent video game is thought to increase aggressiveness through the activation of knowledge structures related to aggression (Barlett et al., 2009). However, the aggression-stimulating effects of the game would only persist long after exposure if players ruminated about violence in the game (Bushman & Gibson, 2011). In the current study, the experimenter collected the games before the second measurement, and no participants reported that they had continued to play the assigned video game thereafter. Thus, once exposure ceased, aggressive cues were no longer present, and aggressive began to subside.

The present study is the first to show the long-term effect of violent video game exposure on brain processes and facial expression recognition. There are some important limitations that should be mentioned. First, the current results were found using only one sample playing one violent video game. Though the violent video game used in the present study is a very popular game, there is a potential limit in our generalization with other forms of game exposure. Another limitation of the study relates to our participants. The current study recruited adult participants who were not regular game players. Therefore, the present data does not conclude how video game violence affects children or adults who are more avid game players. Future studies should address these limitations in order to better provide useful suggestions regarding the usefulness and limitations of certain gaming practices.

5. Conclusion

In conclusion, the present study suggests that playing a violent video game for a long time modulates angry face recognition and increases aggressiveness. Moreover, the follow-up study showed preservation of the modulated facial recognition, while levels of aggressiveness diminished to some extent.

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