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Does excessive play of violent first-person-shooter-video-games dampen brain activity in response to emotional stimuli?

Christian Montag^{a,*}, Bernd Weber^{b,c,d}, Peter Trautner^{b,c}, Beate Newport^b, Sebastian Markt^a,
Nora T. Walter^a, Andrea Felten^a, Martin Reuter^{a,d}

^a Department of Psychology, University of Bonn, Germany

^b Department of Epileptology, University Hospital of Bonn, Germany

^c Department for NeuroCognition, Life & Brain Center, Bonn, Germany

^d Center for Economics & Neuroscience, University of Bonn, Germany

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ABSTRACT

The present case-control study investigated the processing of emotional pictures in excessive first-person-shooter-video-players and control persons. All participants of the fMRI experiment were confronted with pictures from four categories including pleasant, unpleasant, neutral content and pictures from the first-person-shooter-video-game 'Counterstrike'. Compared to controls, gamers showed a significantly lower activation of the left lateral medial frontal lobe while processing negative emotions. Another interesting finding of the study represents the higher activation of frontal and temporal brain areas in gamers when processing screen-shots from the first-person-shooter-video-game 'Counterstrike'. Higher brain activity in the lateral prefrontal cortex could represent a protection mechanism against experiencing negative emotions by down-regulating limbic brain activity. Due to a frequent confrontation with violent scenes, the first-person-shooter-video-gamers might have habituated to the effects of unpleasant stimuli resulting in lower brain activation. Individual differences in brain activations of the contrast Counterstrike > neutral pictures potentially resemble the activation of action-scripts related to the video-game.

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1. Introduction

Young adolescents spend many hours playing violent video games every day. The nature of these games and their potential consequences on psychological functioning are a matter of strong and often emotional public debate. In particular, both mass media reports and diverse research studies focus almost exclusively on so called first-person-shooter-video-games, in which the player moves through warlike scenarios and shoots enemies from a first-person-perspective. Some researchers hypothesized that playing violent video games has an effect on the gamer's real life, e.g. the confrontation with aggression in the video game leads to aggressive behavior in the real world (Gentile and Gentile, 2007). This view was corroborated with meta-analytic studies (Anderson and Bushman, 2001; Anderson et al., 2010) based on behavioral and questionnaire data showing a moderate link between violent video game use and aggressive behavior. While questionnaire and behavioral studies are of importance, new technologies such as

functional magnetic resonance imaging (fMRI) are able to draw a more fine-tuned picture with respect to potential influences of violent video games by providing a link between altered brain activity and violent video gaming. fMRI techniques offer the possibility to test the hypothesis that excessive ego-shooter-gaming results in a blunted response to negative emotional stimuli, thereby preventing empathy and lowering the threshold for aggressive behavior. Interestingly, studies in this important research field are rather scarce. A study by Ko et al. (2009) found that pictures taken from the role-playing game 'World of Warcraft' (WoW) elicit brain activity in excessive gamers which was comparable to activation patterns observed in drug abusers upon confrontation with their drug. Recently, Regenbogen et al. (2010) reported that action video gamers are able to distinguish between real life and virtual scenarios when confronted with images from a first-person-shooter-video-game and similar scenarios set up with actors. Earlier it has been shown that media violence exposure explains individual differences in frontal lobe activation upon participation in a counting stroop task (Mathews et al., 2005). Two other seminal study (Mathiak and Weber, 2006; Weber et al., 2006) recorded brain activity of trained action video gamers when being confronted with different scenarios from an action video game. Even though these studies made significant contributions to the

* Corresponding author at: University of Bonn, Department of Psychology, Kaiser-Karl-Ring 9, D-53111 Bonn, Germany. Tel.: +49 228 73 4309; fax: +49 228 73 62331.
E-mail address: christian.montag@uni-bonn-diff.de (C. Montag).

field, they did not address a crucial point in the ongoing debate: do the violent events experienced in the virtual world affect behavior by an altered neuronal response to emotional stimuli of high ecological validity? Answering this question is important, because dysfunctions in neuronal circuits linked to emotional regulation have been considered to lay ground for violent behavior (Davidson et al., 2000).

The present study aims to investigate the influence of excessive first-person-shooter-video-gaming on the processing of emotions. Several studies have shown before that the presentation of pictures from the International Affective Picture System, briefly called IAPS (Lang et al., 1999) is a simple but effective design to elicit pleasant and unpleasant emotions in and out the fMRI setting (e.g. Montag et al., 2008a,b). If long term excessive gaming is really associated with altered emotional processing, this should lead to changes of the brain response in reaction to such ecological valid emotional stimuli (e.g. a weaker response to unpleasant stimuli) with potential consequences for real life. Furthermore, we included original images from one of the most popular first-person-shooter-video-games called 'Counterstrike®' as a fourth picture category (besides pleasant, unpleasant, and neutral pictures). Since WoW pictures elicited addiction-like brain activity in WoW gamers, we were interested to see if these patterns would also be observable in the present study when confronting 'Counterstrike' gamers with screen-shots from the 'Counterstrike' game. Only males were considered for participation in the present study, because of the low prevalence of female first-person-shooter-video-gamers.

2. Methods and materials

2.1. Participants

In total $N=40$ healthy male participants were included in our fMRI study. Of the 40 subjects, 21 were experienced first-person-shooter-computer-gamers and 19 participants had no history of first-person-shooter-gaming and only little experience with other games (mainly card and sport games). The sample was matched for age and several personality dimensions. The personality questionnaires EPQ-R (Eysenck and Eysenck, 1968) and the anger scale of the ANPS (Davis et al., 2003) were administered (for more information, see supplementary material). The first-person-shooter-video-players were recruited via a prominently placed advertisement on the website of Turtle Entertainment GmbH (<http://www.esl.eu/de>), which is the most prominent online platform for first-person-shooter-computer-gaming in Germany with 2.5 million registered users. The mean age of the sample was 23.33 years ($SD=4.45$). We only included males in the present study due to the extremely low prevalence of female first-person-shooter-video-game-players in the general population. Participants were screened for psychopathological or neurological disorders, which led to exclusion from the study (one participant was not recruited because of Cannabis use). Furthermore, all participants were free of drug use (with the exception of smoking).

One individual in the control group reported having played a first-person-shooter game two or three times seven years ago, which did not lead to exclusion from the control group. Nine of the nineteen participants described themselves as non-players of computer games (i.e. no kind of video-gaming at all). More information on the participants, personality and computer-related variables can be found in Table S1 of the supplementary material. All participants gave written consent to participate in the study. The study was approved by the local medical ethics committee of the University of Bonn, Germany.

2.2. Experimental design

30 images from four picture categories were chosen for a block design fMRI experiment. Altogether, participants saw 24 blocks (four image categories \times six repeats) – each block consisting of five pictures. The picture categories are labeled 'unpleasant,' 'pleasant,' 'neutral' and 'Counterstrike.' We used visual material from the IAPS catalogue (Lang et al., 1999). In order to elicit pleasant emotions, we chose relevant stimuli for males including laughing and cheerful people, holiday scenarios with beaches, and erotic depictions of females. Unpleasant images consisted of disaster and accident scenes, disfigured faces and scenes where humans are attacked. Neutral images included mosaic scenes and objects from everyday life such as a chair or cup. The fourth picture category consisted of 'Counterstrike' images depicting scenarios from the game in which the player is attacked or shoots another person. Although we are aware of the fact that many players use the bloodless version of 'Counterstrike', we used images showing spilled blood after inflicted injuries.

Each picture was presented for 4 s. The pictures in each category were randomly assigned. The same was true for the administration of block order. In order to make sure that participants viewed the pictures and did not close their eyes, each block was followed by a single control picture, where the participants had to push a button to decide if the present control picture had been shown in the preceding picture block or not. Out of 24 possible clicks (as 24 control pictures were shown), participants clicked a mean of 23.31 ($SD=0.60$) times. Gamers did not differ significantly from controls, here. Participants did not differ significantly in their recognition performance either (mean correct answers of all participants: 22.38 ($SD=1.14$)), too. Behavioral data of one person is missing. Thereby, both groups equally viewed and recognized the presented pictures.

2.3. Statistical analyses

2.3.1. Description of sociodemographic variables and MRI analysis

We performed a series of ANOVAs to search for significant differences in personality, sociodemographic variables, computer and action/horror movie consumption between ego-shooter-computer-gamers and controls. As stated previously, age did not differ significantly between first-person-shooter-computer-gamers and controls. Education scores differed significantly ($\chi^2=9.46$, $p=0.03$) with higher education scores in the non-player group. Given the number of tests conducted for personality and sociodemographic variables (see Table S1 in supplementary material), this difference was not significant after correction for multiple testing. Of much greater interest in the context of the present study, is the fact that there were no significant differences in the personality variables of neuroticism, extraversion, psychoticism and anger, which are all known to influence the processing of emotional pictures.

2.3.2. Description of fMRI preprocessing and fMRI analyses

We used an echoplanar imaging (EPI) sequence with the following properties: number of slices = 31, TR = 2.5 s, TE = 45 ms, slice thickness = 3 mm and a 90° flip orientation. The slices were acquired in an AC-PC orientation, with a FOV of 192 mm and were acquired in an ascending manner with a standard 8 channel head coil. The MRI scanner was a Siemens (Erlangen, Germany) Avanto with 1.5 T field strength. Preprocessing of the functional images was implemented using the Matlab based (The MathWorks, Inc.) software SPM8 (<http://www.fil.ion.ucl.ac.uk/spm>) and included realignment, coregistration, slice timing correction and smoothing with an 8 mm filter as well as normalization on MNI standard (Evans et al., 1993, <http://www.bic.mni.mcgill.ca>). General linear models (GLMs) were estimated using a hemodynamic response function (HRF) and a high pass filter of 128 Hz as well as correction for autocorrelations. For the analysis, we defined four regressors of interest per subject in addition to six movement regressors: one for each condition (see above for details). They were entered into a 2nd level random effects model. All results presented were thresholded at $p < 0.05$ FWE-corrected for main effects and $p < 0.001$ uncorrected for group comparison with an extent-threshold of 10 voxels.

3. Results

As a first step, we contrasted the brain activity of the emotional picture conditions with the neutral conditions in the entire sample. The contrasts pleasant > neutral, unpleasant > neutral, and emotion (pleasant and unpleasant taken together) > neutral yielded significant results after conservative FWE correction ($p < 0.05$). Brain activity in limbic areas was especially significant. Please see Tables S3–S5 in supplementary material for exact information on activation clusters. In this context we also contrasted the 'Counterstrike' picture condition with the neutral picture category. Among others, activation clusters in the left and right fusiform gyrus, right medial temporal lobe and left occipital lobe could be observed (FWE corrected, $p < 0.05$). A full description of all significant brain clusters for this contrast can be found in Table S6 of the supplementary material.

The focus of our statistical analyses was to test for differences between the groups of first-person-shooter-video-gamers and control persons regarding the processing of the four picture categories. Here, significantly higher activations could be observed in control persons compared to the first-person-shooter-video-gamers for the processing of negative emotions (contrast unpleasant > neutral, but not the contrast neutral > unpleasant) (see Table 1 and Fig. 1). The largest significant clusters in the control persons could be observed in the left medial frontal lobe, the left medial temporal lobe and the left superior parietal lobe (the complete activation clusters are reported in Table 1; $p < 0.001$, uncorrected, $k > 10$). No group differences in both directions (gamers > controls;

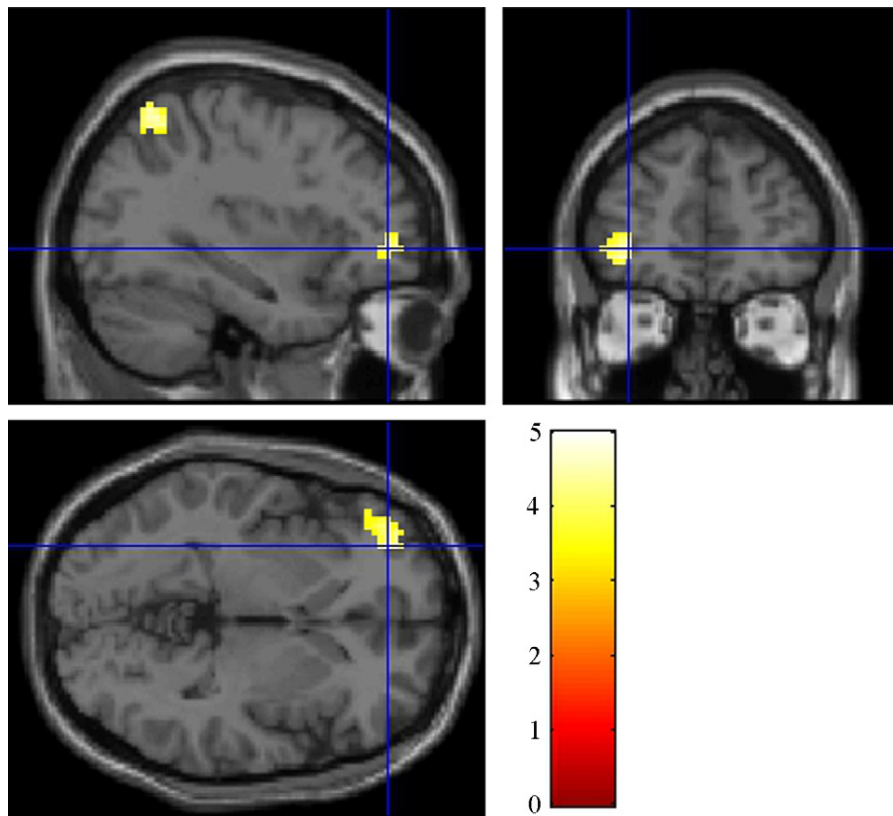


Fig. 1. Significantly higher brain activation in controls compared to first-person-shooter-video-gamers in the contrast unpleasant > neutral pictures ($p < 0.001$, uncorrected, $k > 10$).

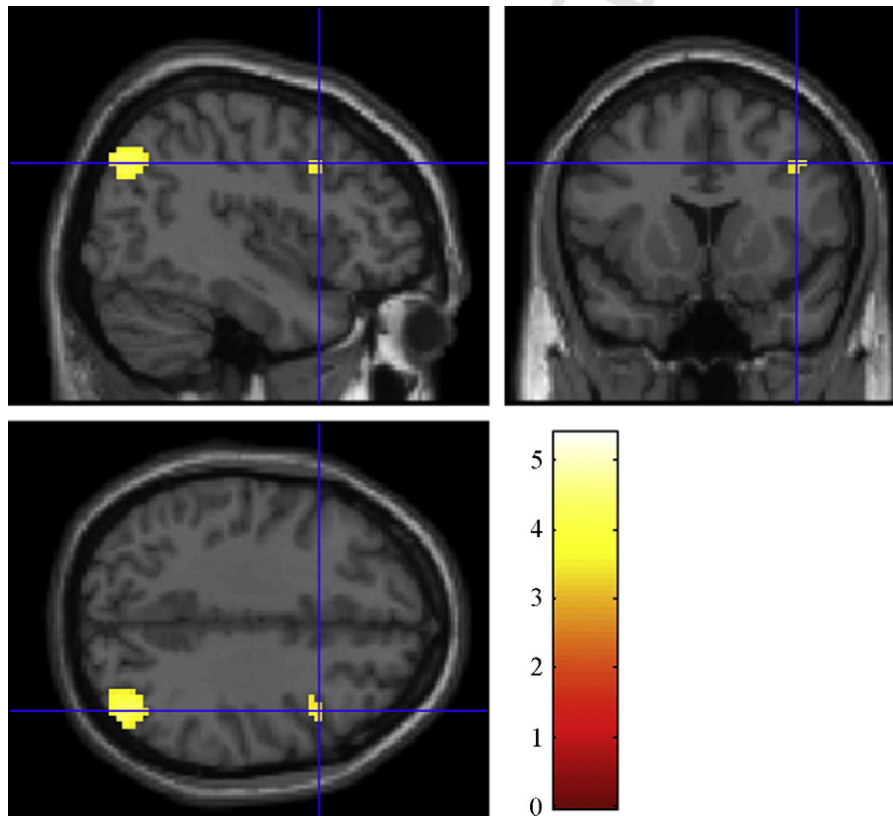


Fig. 2. First-person-shooter-video-gamers had significantly higher brain activations compared with controls in the contrast Counterstrike > neutral pictures in the dorsolateral prefrontal cortex ($p < 0.001$, uncorrected, $k > 10$).

Table 1

Group differences for the contrast negative > neutral pictures ($p < 0.001$, uncorrected, $k > 10$).

	Coordinates of peak (MNI)	Clustersize	Z-score of peak
<i>Control > Gamer</i>			
Right inferior temporal lobe	60/31/17	25	5.00
Left medial frontal lobe	−33/47/−2	72	4.61
Left superior parietal lobe	−33/−58/58	49	4.51
Left medial temporal lobe	−60/−46/−14	46	4.51
Left medial frontal lobe	−48/14/49	5	3.64
Left inferior parietal lobe	−48/−49/52	5	3.56

controls > gamers) for the contrasts pleasant > neutral could be observed. In Table 2, individual differences are shown for the contrast Counterstrike > neutral picture condition. Gamers showed significantly higher activation of several brain clusters in the temporal and frontal lobe ($p < 0.001$, uncorrected, $k > 10$), while the opposite contrast did not show significantly stronger activation in the control group. Please also see Fig. 2.

4. Discussion

The aim of the present study was to investigate the processing of emotions in trained action video players and control persons. We showed that excessive first-person-shooter-video-gamers exhibit differences in the neural processing of unpleasant emotions, likely involving top-down effects on emotional control. A significantly higher activation of the left lateral frontal cortex turned up in the non-gamer group. This brain region is involved in the integration of emotion and cognition (Gray et al., 2002). Thus, the unpleasant IAPS pictures might not have only produced negative emotions in all participants of our study but also triggered a cognitive defense mechanism in the control persons to repress unwanted negative emotions. Recently, a study (Levy and Anderson, 2008) corroborated this idea by showing that activity of the lateral prefrontal cortex is able to suppress unwanted memories. Probably, the stronger brain activity of the lateral prefrontal cortex in the controls compared to gamers reflects the same psychological process in the present picture perception paradigm. Another recent study demonstrated that the lateral prefrontal cortex is also involved in the regulation of attention and awareness processes (Asplund et al., 2010). Given the difference of activity in the lateral prefrontal cortex between our investigated experimental groups, gamers and non-gamers might differ in the experienced salience of the administered unpleasant stimuli. This might be a consequence of a psychological habituation process because the gamer group is confronted with violent scenes more frequently in their daily life. This new finding of a stronger activity of the lateral prefrontal cortex in control persons can be interpreted as a potential resilience factor when dealing with emotional stress (Hooker et al., 2010).

Table 2

Group differences for the contrast Counterstrike > neutral pictures ($p < 0.001$, uncorrected, $k > 10$).

	Coordinates of peak (MNI)	Clustersize	Z-score of peak
<i>Gamers > Controls</i>			
Left calcarine	−6/−55/4	405	5.39
Left insula	−33/−10/22	21	4.88
Right medial occipital cortex	42/−76/37	101	4.35
Left medial temporal lobe	−63/−49/7	9	4.21
Right superior temporal lobe	51/−37/7	16	3.99
Left inferior temporal lobe	−57/−58/−8	15	3.95
Right supramarginal cortex	66/−37/40	7	3.77
Right olfactory cortex	3/17/−2	9	3.75
Right inferior frontal cortex	48/35/13	6	3.72
Right frontal inferior cortex	42/14/37	13	3.65

Alternatively, the lower activity of the lateral prefrontal cortex in gamers can be interpreted as a dampening of experienced empathy elicited by the harm of a third person. In line with this, several studies demonstrated that the lateral prefrontal cortex is also involved in the evaluation and labeling of emotions (Lieberman et al., 2007; Ochsner et al., 2002), and therefore serves psychological functions of high importance in social interactions. In line with our findings are also the observations (Mathews et al., 2005) reporting lower frontal activations in participants with high media violence exposure in a cognitive counting stroop task.

The findings are also of interest in the context of Gray and McNaughton's revised reinforcement sensitivity theory (2000). Both authors argue that a behavioral inhibition system (BIS) is triggered in situations of high uncertainty leading to careful approach behavior. This careful approach behavior is shown by the organism to gain more insights on the possible dangerousness of the uncertain situation. It could be argued that experienced first-person-shooter-video-players are characterized by a habituated BIS circuit in response to unpleasant (and violent) scenes with the consequence of disinhibited behavior towards such stimuli. This idea clearly warrants more research in the future, because the BIS system is strongly anchored in the hippocampal-amygdala circuit and the present findings refer to differences in the top-down regulation of emotions linked to the prefrontal cortex.

A second aim of the study was to investigate the brain activity when gamer and control persons are confronted with images from the 'Counterstrike' first-person-shooter-video-game. The group of first-person-shooter-gamers showed significantly higher activation of both frontal and temporal areas for the contrast 'Counterstrike' vs. neutral pictures. This was not in line with our hypothesis, because we hypothesized addiction-like brain activity, as observed in WoW players (Ko et al., 2009). The observed higher activity in the dorsolateral prefrontal cortex and temporal lobe areas in first-person-shooter-video-gamers might reflect the planning of game moves related to the 'Counterstrike' computer game which is accompanied by an activation of both working memory as well as the processing of game-relevant information from long term memory. Therefore, higher activity in the dorsolateral prefrontal cortex and temporal lobe areas in the experimental group reflects automatized neuronal processing relevant for a successful outcome in ego-shooter games.

In sum, to our knowledge the present study for the first time investigated the influence of excessive first-person-shooter-video-gaming on the processing of emotions by using emotional pictures of high ecological validity. Control persons showed a significantly higher activation of the lateral prefrontal cortex potentially reflecting a repression strategy with regard to unpleasant stimuli, which is missing in the computer gamers. Moreover, the expert 'Counterstrike' gamers showed a stronger activation of dorsolateral prefrontal cortex and temporal areas of the brain in reaction to 'Counterstrike' pictures, which might reflect the activation of action scripts related to the first-person-shooter-video-game. A limitation of the present study is its correlational nature; longitudinal studies or action video training studies such as reported in the context of cognition (Green et al., 2010) are needed in order to establish causality in the hypothesis that gaming leads to differences in brain activity. However, given the careful selection of the participants in the present study (excessive gamers vs. controls not differing in gender, age or personality variables) and the corroborating evidence from other studies, it is likely that the observed effects are a consequence of gaming.

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309 Appendix A. Supplementary data

310 Supplementary data associated with this article can be found, in
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