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Emotion Recognition and Inhibitory Control in Adolescent Players of Violent Video Games

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Developmental changes during adolescence may make youth susceptible to violent media effects. Two studies with male adolescents (N_1 = 241; N_2 = 161; aged 12–17) examined how habitual and short-term violent video gaming may affect emotion recognition and inhibitory control. We found that not habitual exposure to violent video games, but to antisocial media content predicted worse emotion recognition. Furthermore, higher habitual exposure to violent games predicted better inhibitory control over emotional stimuli in a stop signal task. However, short-term causal effects of violent gameplay on adolescents were not found. While these results do not indicate a negative impact of violent video games on young players, future research may further investigate possible effects of antisocial media content on adolescents.

Key words: violent video games – emotion recognition – inhibitory control

Video games are among the most popular means of digital entertainment and are subject of ongoing debates among scholars and policy makers. Playing video games may have positive effects (Granic, Lobel, & Engels, 2014; Halbrook, O'Donnell & Msetfi, 2019), especially on cognitive performance, such as selective attention (Green & Bavelier, 2003). However, the main concerns of the public debate are focused on the effects of violent video games on young players' well-being (Lobel, Engels, Stone, Burk, & Granic, 2017) and possible aggressive behavior (Copenhaver, Mitrofan, & Ferguson, 2017). This is in line with the General Aggression Model (Allen, Anderson, & Bushman, 2018; Anderson & Bushman, 2002), which states that repeated violent video game exposure would result in aggressive behavior. However, not all studies on youth aggression and violent video games support the General Aggression Model (cf. Ferguson et al., 2015). Moreover, meta-analyses indicated only very small effects of violent video games on children and adolescents' aggression in correlational (r = .04), experimental (r = .09), and longitudinal studies (r = .08) (Ferguson, 2015; Prescott, Sargent, & Hull, 2018). In addition to the small effect sizes, research on violent video games and aggression suffers from publication bias (Hilgard, Engelhardt & Rouder, 2017), unstandardized measures of aggression (Elson, Mohseni, Breuer, Scharkow, & Quandt, 2014), and no consensus among scholars regarding aggressive outcomes of violent games (Ivory et al., 2015). These issues make the available evidence in the field ambiguous, whereas its societal and scientific relevance warrants further study on the effects of violent video games on adolescents.

Therefore, the current work focused on more subtle and indirect changes that might be affected by exposure to violent video games (Ferguson & Konijn, 2015). Specifically, we investigated the recognition of emotional faces and the inhibition of reaction over emotional stimuli. In a correlational Study 1, we aimed to test the relationships of habitual exposure to violent video games with emotion recognition and inhibitory control. In an experimental Study 2, we aimed to test the short-term effects of violent video gameplay on emotion recognition and inhibitory control. In both studies, we focused on adolescents: 12- to 17-year-old boys. We selected this age group for two reasons: because of a high prevalence of (violent) video gaming among teenagers (Rideout, 2015), and because adolescence as a key period for social development (Blakemore & Robbins, 2012). Adolescents are especially sensitive to negative emotional stimuli, which could play an important role in the development of inhibitory control and emotion recognition (Cohen-Gilbert & Thomas, 2013; Tottenham, Hare, & Casey, 2011). Theoretically, such emotional sensitivity could be

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decreased by exposure to violent video games, resulting in desensitization, which might have an impact on social cognition and underlie (anti)social behavior (Carnagey, Anderson, & Bushman, 2007). However, early adolescents were rarely tested in this context. Therefore, the current work would extend previous research, by investigating whether younger players are more susceptible to violent video game effects than late adolescents.

Adolescent Players of Violent Video Games

In general, adolescence is a sensitive period for social and cognitive skill development (Blakemore & Robbins, 2012; Crone & Dahl, 2012). This sensitivity may explain why adolescents might be especially susceptible to violent media effects (Crone & Konijn, 2018; Konijn, Veldhuis, Plaisier, Spekman & den Hamer, 2015). Developmental changes in adolescents' brains make them hypersensitive to rewards (Blakemore & Robbins, 2012; Padmanabhan, Geier, Ordaz, Teslovich, & Luna, 2011; Telzer, 2016). This is important in the context of (violent) video games, which provide adolescents with immediate feedback and rewards for successful game performance (Konijn & Achterberg, 2020). However, adolescents' hypersensitivity to rewards, goal flexibility, and increased brain plasticity could work as a double-edged sword in the context of video gameplay (Fuhrmann, Knoll, & Blakemore, 2015). While it may create opportunities for adolescents to learn different skills by playing video games, it may also increase possible susceptibilities when it comes to playing violent first-person shooting games or fighting games. Given that such games reward violent in-game actions, violent game exposure may in turn affect adolescent players' emotional, cognitive, and self-regulatory processes such as emotion recognition and inhibitory control over emotional stimuli.

Emotion Recognition

Emotion recognition plays a crucial role in affectively understanding others. The ability to adequately recognize negative emotions in people, for example, seeing a victim in distress, initiates an accurate reaction that may work as a 'violence inhibition mechanism', limiting the probability of violent behavior and increasing prosocial tendencies (Blair, 1995; Blair, Colledge, Murray, & Mitchell, 2001). Deficits in recognition of negative emotions were found in samples characterized with antisocial behavior problems (Marsh & Blair, 2008), for example, in adolescent offenders (Bowen, Morgan, Moore, & van Goozen, 2014; Gonzalez-Gadea et al., 2014) and in children with disruptive behavior diagnosis (Hunnikin, Wells, Ash, & van Goozen, 2019). Emotion recognition was found to be related to trait empathy (Besel & Yuille, 2010). Further, emotion recognition shows an ongoing development throughout adolescence (Thomas et al., 2007), which is accompanied by changes in cerebral white and gray matter volume (Kilford, Garrett, & Blakemore, 2016). Research suggests existing gender differences in emotion recognition development: adolescent boys were in general slower and less sensitive to emotional expressions (Lee et al., 2013), as well as less accurate in recognition of emotions than girls (Tottenham et al., 2011).

Inhibitory Control

Inhibitory control refers to the ability to inhibit inappropriate reactions to (emotional) impulses (Muraven, 2012) and is an important skill to limit potential aggressive behavior (cf. I^3 theory, Slotter & Finkel, 2011). Problems with inhibitory control were found in samples characterized by aggressive behavior, such as violent male adult offenders (Meijers, Harte, Meynen, & Cuijpers, 2017) and juvenile offenders (Chen, Chiou, & Ko, 2019; Zhang, Wang, Liu, Song, & Yang, 2017). Development of inhibitory control during adolescence is driven by changes in relevant brain networks (Blakemore & Robbins, 2012; Casey & Caudle, 2013; Constantinidis & Luna, 2019), for example, maturation of the prefrontal cortex, a key brain region involved in inhibition. Disruption of inhibitory control development may have serious impact on adolescents' future life. For example, a longitudinal study found that lower levels of inhibitory control in early adolescence predicted higher risk of delinquency in the future (from middle adolescence to emerging adulthood) (Fosco, Hawk, Colder, Meisel, & Lengua, 2019). Given the risk of exposure to violent games to enhance aggressive tendencies (Allen et al., 2018), it is important to study inhibitory control as a possible underlying mechanism of such exposure in adolescents. Further, according to the reflective impulsive model (Hofmann, Friese, & Strack, 2009; Strack & Deutsch, 2004), multiple repetitions of the same actions may stimulate automatic schemata of behavior, supporting impulsive reactions and lowering chances for successful inhibitory control. Based on these insights, we expected that frequent repetitions of violent actions in a game would contribute to automatization of such actions, decreasing inhibitory control capacities.

Furthermore, inhibitory control is an effortful act and may become even more challenging when one faces distractors such as negative emotional content (Kalanthroff, Cohen, & Henik, 2013). The ability to accurately regulate one's negative emotions is crucial in successfully inhibiting impulsive aggressive actions (Davidson, Putnam, & Larson, 2000). For instance, problems with inhibitory control over emotional faces (angry vs. neutral) were found in adults with higher trait aggressiveness (Pawliczek et al., 2013). In addition, lower disgust sensitivity predicts higher levels of aggression (Pond et al., 2012).

Developmental research highlights gender differences and improvements in emotion regulation from adolescence to adulthood (Cohen-Gilbert & Thomas, 2013; Tottenham et al., 2011), marked in adolescents with a decreased activity of the ventromedial prefrontal cortex, involved in affect regulation (Hare et al., 2008). Moreover, age-related differences in inhibitory control over emotional faces marked early adolescence as a period when youth's inhibition may be especially sensitive to negative emotional stimuli (Cohen-Gilbert & Thomas, 2013). However, the existing literature is divided about the effect of negative emotions on inhibitory control in adolescents: whether negative emotions may disrupt inhibitory control or facilitate it (Farbiash & Berger, 2016).

Given that negative emotional stimuli occur frequently in violent video games, we were interested in examining emotion recognition and inhibitory control over negative emotional stimuli in adolescents as important cognitive and affective processes that may be affected by playing violent video games. Because adolescent boys and girls differ in emotion recognition (Lee et al., 2013), inhibitory control over emotional faces (Tottenham et al., 2011), as well as in exposure to violent video games (Rideout, 2015), we focused on adolescent boys only to avoid gender as a possible cofounding factor in the current study.

Emotion Recognition, Inhibitory Control, and Violent Video Games

Several studies have explored emotion recognition and inhibitory control in the context of playing violent video games. Most previous studies on emotion recognition in this context focused on reaction times; participants were asked to detect as fast as possible a change in emotional expression in a morphing faces paradigm. Earlier studies found that faster recognition of faces morphing from neutral to angry than from neutral to happy was related to exposure to media violence (Kirsh, Mounts, & Olczak, 2006) and was a short-term effect of violent video gameplay (Kirsh & Mounts, 2007). However, a recent cross-sectional study using the same morphing face paradigm showed no differences in recognition of sadness vs. anger or pain vs. happiness between players of action violent games and non-video game players (Pichon et al., 2020). Furthermore, a cross-sectional study using a different facial recognition task found that participants highly exposed to violent games recognized disgusted faces less accurately than the control group (Diaz, Wong, Hodgins, Chiu, & Goghari, 2016). However, they also recognized fearful expressions more accurately and faster than nongamers. This was explained by gamers' faster recognition of fear that would indicate a virtual danger to which they are alerted to quickly respond in order to reach their in-game goals. Given the limited and mixed evidence on the accuracy of emotion recognition in the violent gaming context, we aimed to contribute to the existing literature by examining how exposure to violent media content and violent games would relate to (Study 1) and affect (Study 2) accuracy of recognizing negative facial expressions in a relatively large adolescent sample.

Until now, a correlational study showed that exposure to violent media content can be related to lower inhibition performance in a Stroop task especially in adolescents diagnosed with disruptive behavior disorder (Kronenberger et al., 2005). Moreover, an experimental study using a go/no-go task during functional magnetic resonance imaging found lower brain activity in the right dorsolateral prefrontal cortex in adolescents who played a violent video game (vs. a nonviolent game), possibly indicative of reduced inhibitory control abilities (Hummer et al., 2010).

An interesting avenue to further investigate the effects of violent video games on inhibitory control is using emotional stimuli. Theoretically, there are two possible effects of violent video games in this context. First, habitual violent video game exposure may dysregulate inhibitory control over negative emotional stimuli due to stimulation of automatic schemata of behavior. On the other hand, exposure to violent video games could make players insensitive to emotional stimuli (Carnagey et al., 2007), which could lead to better inhibitory control over emotional stimuli. Thus far, results on this topic using different neuroimaging approaches and behavioral tasks are mixed.

In two functional magnetic resonance imaging studies, adolescents performed an emotional Stroop task. An experimental study indicated that short-term violent gameplay (vs. nonviolent gameplay) led to higher involvement of the right amygdala and lower activity in the medial prefrontal cortex, suggesting stronger emotional distraction (Wang et al., 2009). In contrast, a correlational study found a relationship between lower activation of the right amygdala and higher habitual media violence exposure (Kalnin et al., 2011), suggesting lower sensitivity to violent words. Further, in two studies, adults performed an emotional Stop Signal Task with event-related potential measurements. Both studies found lower amplitudes of brain activity over happy expressions related to habitual violent gaming (Stockdale, Morrison, Palumbo, Garbarino, & Silton, 2017) and as a result of watching a violent movie compared with a nonviolent movie (Stockdale, Morrison, Kmiecik, Garbarino, & Silton, 2015). This suggests that players of violent games used less cognitive resources to inhibit behavior over happy stimuli. However, no behavioral differences (in reaction times) were found between happy and fearful faces during the emotional Stop Signal Task (Stockdale et al., 2015, 2017).

A possible mismatch between the described findings could be due to the use of a different task: emotional Stroop task vs. emotional Stop Signal Task. Previous study indicated low intercorrelations between the Stroop task and Stop Signal Task among adolescents (Khng & Lee, 2014), suggesting that these tasks measure different aspects of inhibitory control. Moreover, developmental differences in inhibitory control over emotional stimuli between adolescents and adults could also contribute to such mismatch between previous findings. Finally, an important factor could be differences in exposure to violent video games (habitual vs. experimental; Engelhardt et al., 2011).

In all, these results indicate that adolescents, as avid video game players, are of special interest to study the effects of violent video games on inhibitory control over emotional stimuli. While the discussed above results are based on correlational and experimental studies with late adolescents and adults, it has not yet been examined in early-late adolescents with the emotional Stop Signal Task.

Current Study

Addressing the gaps mentioned above, the aim of the current studies was to test whether violent video game exposure is associated with and affects emotion recognition and inhibitory control in adolescents (aged 12–17). Specifically, we tested whether exposure to violent video games would be related to (Study 1; H1) and would result in (Study 2; H2) less accurate emotion recognition and weaker inhibitory control skills in adolescents. Moreover, in both studies, we were interested in the age of participants as a possible moderating factor, expecting that the effect of violent video games would become less pronounced with age from early to late adolescence (H3). Further, we explored general exposure to antisocial media content as an additional predictor (Study 1) and a moderator (Study 2) (RQ1). Finally, habitual violent video game exposure was explored as a moderator of short-term experimental exposure to violent (vs. nonviolent) video game content (Study2; RQ2). We did not have a specific expectation regarding the direction of this moderation, since we did not preselect participants with high vs. low levels of habitual violent video game exposure for Study 2. Theoretically, the moderation could reflect either an increased or a decreased sensitivity to the short-term exposure in participants with high levels of habitual violent video game exposure (Engelhardt et al., 2011; Stockdale et al., 2017).

STUDY 1

The first study aimed to test how habitual violent video game exposure would relate to emotion recognition and inhibitory control over emotional stimuli in a correlational design.

Method

Participants. Dutch adolescent boys ($N = 241$; power analysis in Supplementary Materials), aged 12 to 17 years ($M = 14.16$; $SD = 1.37$), participated in this study. Active consent was obtained both from all participants and their parents. The study was approved by the Institutional Ethical Review Board.

Procedure. Participants were tested in individual conditions at a school laboratory. They filled in a survey measuring general exposure to video games, antisocial media content exposure, violent video game exposure, and the personality traits: empathy, sensation seeking, and physical aggressiveness. Next, they completed three computer tasks. The first two tasks (Inquisit 4, 2015) measured inhibitory control and emotion recognition in a randomized order. The last task measured perspective taking (discussed elsewhere). After completing about 30-min procedure, participants were debriefed and rewarded.

Materials. *Emotion recognition.* The Facial Expressions Matching Test (FEMT; Szczygieł, Buczny, & Bazińska, 2012) was used to assess recognition of four negative facial expressions: disgust, fear, anger, and sadness, presented by both female and male actors (Ekman & Friesen, 1976). The participant's task was to match the emotional expression presented in the center of a computer screen with one of the three emotional expressions presented at the bottom of the screen (Figure S1). There was only one correct answer per trial. In all, participants responded in 14 randomized trials to 56 pictures of emotional faces (in sets of four). The task started with two training trials with feedback on correct or incorrect answers followed by 12 experimental trials without feedback. Participants were instructed to respond the most accurate and fastest as they could. However, there was no time limit and each trial was displayed until a response was given. Therefore, the reaction times of emotion recognition (in milliseconds) are treated as an additional measure in this task. Correctness of facial expression recognition is considered as the main indicator in the FEMT.

Inhibitory control. A modified version of the Stop Signal Task (Verbruggen & Logan, 2008; Verbruggen, Logan, & Stevens, 2008) was used to assess inhibitory control over emotional stimuli by including pictures of emotional faces to the emotional Stop Signal Task (Buczny & Miedzobrodzka, 2019; Pawliczek et al., 2013). An assumption of the task is that processing of emotional faces may interfere with an ongoing inhibition process (Kalanthroff et al., 2013; Verbruggen & De Houwer, 2007). The task consisted of three blocks: (1) a training block with feedback (10 trials), and two blocks in randomized order; (2) disgust vs. neutral faces (38 trials); and (3) angry vs. neutral faces (38 trials).

Examples of go and stop trials in both blocks are presented in Figure 1. In the go trials, participants were instructed to react as fast as possible to the appearing faces (go stimuli) by pressing "E" keyboard button when they saw an emotional face and pressing "N" keyboard button when they saw a neutral face. In the stop trials, when a stop signal was presented through headphones, they were asked to inhibit their response and not press any button. Proportion of go trial to stop trials was 75%–25%, respectively.

An indicator of inhibitory control was the average Stop Signal Reaction Time (SSRT). Weaker inhibitory control was reflected with higher SSRT, meaning that a person needed more time to successfully inhibit a reaction. SSRT was calculated automatically in milliseconds (ms) only for the stop trials at the end of each block, separately for anger and disgust blocks (Verbruggen et al., 2008). Because we did not have a specific expectation for different emotions, SSRT for disgusted faces and angry faces were averaged into SSRT average (DV) (Figure 1).

Measures. *Frequency of gaming.* Participants were asked two questions about their frequency of playing video games on an average weekday (scale from 1 = "0 hours" to 9 = "7 hours or more") and

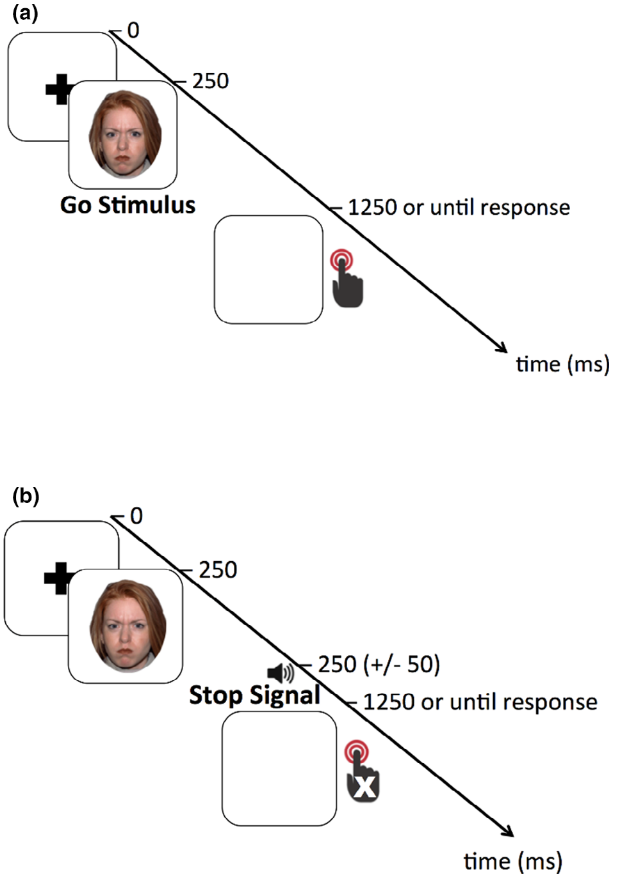

FIGURE 1 Examples of a go trial (a) and a stop trial (b) in the emotional Stop Signal Task (emoSST; Buczny & Miedzobrodzka, 2019). In total, 72 pictures from the NimStim dataset (Tottenham et al., 2009) presenting disgust, angry, or neutral faces (24 per each emotion) were used in the emoSST.

on an average weekend day (scale from 1 = "0 hours" to 8 = "11 hours or more") (den Hamer, Konijn, & Bushman, 2017; Rideout, Foehr, & Roberts, 2010).

Habitual violent video game exposure (VVGE). Participants were asked to do the following: (1) name their three favorite video games; (2) rate how frequently they played each title (1 = *almost never*, 5 = *almost every day*); and (3) rate how violent they consider each named video game (1 = *not violent at all*, 4 = *very violent*) (Andersen & Dill, 2000). Pan European Game Information (PEGI) ratings were used to evaluate every video game title named by a participant to provide an objective measure of violent content (Busching et al., 2015). Each game containing violence (violence PEGI label) and age label 12+, 16+, or 18+ was coded as a violent game (coded as 1, 2, and 3, respectively). Each game not containing violence (no violence PEGI label) and age label 3+, 7+, or 12+ was coded as a nonviolent game (coded as 0). Frequency of playing violent video games was summed. The final violent video game exposure index was computed as a multiplication of the sum of frequencies of playing *violent* video games with the sum of the *objective* violent content rating (based on PEGI), divided by the number of *violent* video games named by a participant, and was used as a continuous variable in all analyses.

We introduced several improvements to the VVGE index by Anderson and Dill (2000). First, our index was based on the objective PEGI violent content ratings, also ensuring that the same game was rated in the same way across the whole sample. The scale of the violent content rating ranged from 0 (3+, 7+, 12+, nonviolent) to 3 (18+, violent), ensuring that exposure nonviolent games would not influence the final score. Moreover, our rating was based only on the frequencies of playing violent video games, excluding the frequencies of playing nonviolent video games. Finally, we took into account only the number of the *violent* video games named by participants, and not all games.

Antisocial content media exposure. Antisocial content media exposure (CME) was measured with the antisocial subscale (12 items) of the Content-based Media Exposure questionnaire (den Hamer et al., 2017), validated for adolescent samples. Sample item: 'How often do you watch (on the Internet/TV/games/mobile phone/DVD) people who shoot at another person?' Scale ranged from 1 (*never*) to 5 (*very often*). Cronbach's alpha = .89. We included this subscale to examine whether habitual exposure to violence in all sorts of media could contribute to the expected effects of violent video games.

Trait empathy. A short version of the basic empathy scale (Jolliffe & Farrington, 2006) in Dutch translation (den Hamer et al., 2017) was used to measure trait empathy. Participants were asked to indicate how much they agree with 10 items on a 5-point scale ranging from 1 (*does not describe me at all*) to 5 (*describes me very well*). An example item: 'I get easily carried away by the feelings of others.' A higher score on this scale reflects higher trait empathy; Cronbach's alpha (this study) = .56.

Trait sensation seeking. Trait sensation seeking was measured with a questionnaire of Stephenson, Hoyle, Palmgreen, and Slater (2003) with three added items (e.g., 'I wish my life was more exciting') in Dutch translation (den Hamer et al., 2017). Scale ranged from 1 (*does not describe me at all*) to 5 (*describes me very well*); Cronbach's alpha = .88.

Trait aggressiveness. The physical aggression subscale of the Aggression Questionnaire (Buss & Perry, 1992) in Dutch translation (Konijn, Nije Bijvank, & Bushman, 2007) was used. The subscale consisted of nine items, for example: 'I get into fights a little more than the average person'. Scale ranged from 1 (*does not describe me at all*) to 5 (*describes me very well*); Cronbach's alpha = .84.

Analysis plan. All analyses were performed in SPSS, version 26 (IBM SPSS Statistics, version 26.0: IBM Corp, Armonk, NY, USA). The main hypotheses were tested with hierarchical regressions because the main predictor (habitual violent video game exposure) was continuous. Further, by applying step-by-step multiple hierarchical regression, we could test possible effects of other variables of interest. Given the different covariates for each dependent variable, we ran two separate regression models. We used trait empathy as a covariate in the analyses for emotion recognition as empathy is related to emotion recognition skills (Besel & Yuille, 2010). We used trait physical aggressiveness as a covariate for inhibitory control analyses since this trait may affect inhibitory control (Pawliczek et al., 2013) and predict automatic reactions toward angry faces (Veenstra, Schneider, Bushman, & Koole, 2016). All variables included in the regressions were mean-centered to avoid multicollinearity.

Emotion recognition. To test H1a, a hierarchical regression was performed with emotion recognition correctness (% of correct responses) as a dependent variable, including the following predictors in separate steps: (1) VVGE; (2) age; (3) antisocial CME; (4) trait empathy; and (5) two interactions: VVGE x age and antisocial CME × age.

Inhibitory control. To test H1b, a hierarchical regression was performed with Stop Signal Reaction Time average (measured in milliseconds; ms) as a dependent variable, including the following predictors in separate steps: (1) VVGE; (2) age; (3) antisocial CME; (4) trait physical aggressiveness; and (5) two interactions: VVGE x age and antisocial CME × age. Two exploratory hierarchical regressions applied the same predictors for SSRT for the two emotion types separately (i.e., SSRT disgust and SSRT anger; see Supplementary Materials).

Results

Preliminary analyses. Descriptive statistics including all measures are presented in Table 1. See Supplementary Materials for details of frequencies of (violent) video gaming (Tables S1–S3) and zero-order correlations (Table S4).

Hypotheses testing. *Emotion recognition.* Results of the hierarchal regression analysis revealed that habitual violent video game exposure was not associated with emotion recognition accuracy, failing to support H1. However, higher exposure to antisocial media content was related with less accurate emotion recognition (RQ1). Furthermore, older age predicted more accurate emotion recognition, reflecting developmental differences in this skill. Also, higher trait empathy (covariate) was related to more accurate emotion recognition. Finally, interactions between habitual violent video game exposure by age and antisocial media content exposure by age were not significant, not supporting H3. Details of this analysis are presented in Table 2. Moreover, in order to show the effects of habitual exposure to violent video games and antisocial media exposure as main predictors separately, we run two additional regression analyses (see Supplementary Materials, Table S5), which confirmed the main findings.. *Inhibitory control.* Results of the hierarchal regression analysis for inhibitory control revealed that both habitual violent video game exposure and antisocial media content exposure were significantly related with inhibitory control. However, contrary to the expectations (H1; RQ1), higher levels of habitual violent video game exposure and antisocial CME were related to *better* inhibitory control (shorter SSRT). Results of regressions for two separate Stop Signal Task blocks (anger and disgust; Table S7) were in line with the results for the SSRT average. Furthermore, age significantly predicted inhibitory control, reflecting the developmental differences between participants such that younger adolescents had weaker inhibitory control (longer SSRT) than late adolescents. The effect of trait physical aggressiveness (covariate) was not significant. Finally, interactions between habitual violent video game exposure by age and antisocial media content exposure by age were not significant, not supporting H3. Details of this analysis are presented in Table 3. Moreover, the results of additional regression analyses for violent video game exposure and antisocial media content exposure as separate predictors showed the same results (Table S6). Finally, the results of additional regressions for two separate emotional Stop Signal Task blocks (anger and disgust) were in line with the main results (Table S7).

TABLE 1
Mean Values and Standard Deviations of the Main Variables in the Study 1 (N = 239) and the Study 2 (N = 161)

Variable	*Study 1* M (SD)	*Study 2* M (SD)
1. VVGE	14.58 (8.28)	14.14 (10.06)
2. CME	2.39 (0.75)	2.15 (0.75)
3. Age	14.16 (1.37)	13.66 (1.11)
4. Empathy	3.09 (0.49)	3.15 (0.46)
5. Aggression	2.19 (0.76)	2.07 (0.80)
6. S.Seeking	2.35 (1.01)	2.41 (1.02)
7. FEMT.CORR	66.37 (13.00)	67.81 (13.03)
8. FEMT.RT	3946.32 (2236.14)	4237.99 (2218.66)
9. SSRT.Ave	452.23 (89.73)	476.63 (99.64)
10. SSRT.Disgust	439.48 (97.05)	470.49 (113.77)
11. SSRT.Anger	464.98 (104.80)	482.77 (109.44)

Note. Aggression = trait aggressiveness; CME = antisocial content media exposure; Empathy = trait empathy; FEMT.CORR = correctness of emotion recognition in the Facial Expression Matching Test (FEMT; %); FEMT.RT = mean reaction time of emotion recognition in the FEMT (in milliseconds); S.Seeking = trait sensation seeking; SSRT.Anger = Stop Signal Reaction Time for angry faces (emoSST; ms); SSRT.Ave = SSRT average; SSRT.Disgust = Stop Signal Reaction Time for disgust faces (emoSST; ms); VVGE = violent video game exposure.

Conclusion

The results indicated that *not* habitual exposure to violent video games, but exposure to antisocial content in different sorts of media was related to lower accuracy of emotion recognition in adolescents. Moreover, older adolescents were better in emotion recognition, reflecting developmental

TABLE 2
Hierarchical Regression Analysis Predicting Correctness of Emotion Recognition as Measured with the FEMT (Study 1; $N = 229$)

	FEMT Correctness						
	ΔR^2	B	SE	β	t	p	*95% CI*
Step 1	.000						
VVGE		.00	.00	.012	0.18	.858	[–.002, .002]
Step 2	.007						
VVGE		.00	.00	.002	0.03	.975	[–.002, .002]
Age		.01	.01	.083	1.25	.214	[–.004, .020]
Step 3	.024†						
VVGE		.00	.00	.018	0.27	.787	[–.002, .003]
Age		.01	.01	.121	1.76	.077	[–.001, .024]
CME		–.03	.01	–.162	–2.38	.018	[–.056, –.003]
Step 4	.036**						
VVGE		.00	.00	.072	1.06	.288	[–.001, .004]
Age		.01	.01	.135	2.02	.045	[.001, .025]
CME		–.03	.01	–.160	–2.39	.017	[–.055, –.003]
Empathy		.06	.02	.199	2.95	.004	[.018, .096]
Step 5	.005*						
VVGE		.00	.00	.080	1.17	.243	[–.001, .004]
Age		.01	.01	.136	2.03	.044	[.001, .026]
CME		–.03	.01	–.153	–2.27	.024	[–.055, –.002]
Empathy		.06	.02	.204	3.00	.003	[.019, .097]
VVGE × Age		.00	.00	–.035	–0.53	.598	[–.002, .001]
CME × Age		.01	.01	.067	1.00	.318	[–.008, .027]
Total adj. R^2	.047*						

Note. CME = antisocial content media exposure; Empathy = trait empathy. CI based on 5000 bootstrap samples; VVGE = violent video game exposure.
$^{\dagger}p < .1$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$.

TABLE 3
Hierarchical Regression Analysis Predicting Inhibitory Control as Measured with the emoSST (Study 1; $N = 228$)

	SSRT Average						
	ΔR^2	B	SE	*β*	t	p	*95% CI*
Step 1	.028*						
VVGE		–1.87	0.73	–.168	–2.57	.011	[–3.251, –0.432]
Step 2	.038***						
VVGE		–1.59	3.72	–.143	–2.22	.028	[–2.948, –0.158]
Age		–12.85	4.22	–.197	–3.05	.003	[–20.864, –4.852]
Step 3	.022***						
VVGE		–1.422	0.72	–.128	–1.99	.048	[–2.802, 0.006]
Age		–10.57	4.29	–.162	–2.46	.014	[–18.924, –2.311]
CME		–18.49	7.87	–.155	–2.35	.020	[–34.376, –3.628]
Step 4	.003***						
VVGE		–1.49	0.72	–.134	–2.07	.040	[–2.861, –0.072]
Age		–10.18	4.31	–.156	–2.36	.019	[–18.474, –1.837]
CME		–21.68	8.68	–.182	–2.50	.013	[–39.907, –3.917]
Aggression		7.27	8.36	.062	0.87	.386	[–10.135, 24.607]
Step 5	.013***						
VVGE		–1.56	0.72	–.141	–2.17	.031	[–2.932, –0.132]
Age		–10.59	4.32	–.163	–2.45	.015	[–19.156, –2.303]
CME		–22.81	8.68	–.191	–2.63	.009	[–40.613, –4.371]
Aggression		5.19	8.46	.044	0.61	.540	[–12.660, 22.429]
VVGE × Age		0.06	0.51	.007	0.12	.909	[–.785, 0.998]
CME × Age		–10.95	6.03	–.120	–1.82	.071	[–21.772, –0.712]
Total adj. R^2	.081***						

Note. CI based on 5000 bootstrap samples. Aggression = trait physical aggressiveness; CME = antisocial content media exposure; VVGE = violent video game exposure
$^{\dagger}p < .1$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$.

differences in this skill. These results hold while controlling for trait empathy, which was positively related to emotion recognition. Finally, exposure to antisocial media content or habitual violent video game exposure did not interact with age, indicating that the influence of media exposure does not change from early to late adolescence.

Contrary to our hypothesis, both higher levels of exposure to violent games and violent content in general media *better* inhibitory control. Perhaps, exposure to violent media content, especially violent games, made adolescents less sensitive to emotional stimuli, which in turn resulted in better inhibitory control over negative facial expressions. Results also showed that inhibitory control increased with age, reflecting the developmental maturation of this skill. Finally, no interactions were observed between age and exposure to violent video games or violent media content in general, indicating that the influence of media exposure on inhibitory control does not change during the transition from early to late adolescence. Insights from the Study 1 are further considered in the general discussion. Since no causality can be inferred from the correlational findings from Study 1, we performed an experimental study to investigate any causal link between violent video games with emotion recognition and inhibitory control.

STUDY 2

The aim of the second study was to test in an experimental setting whether short-term exposure to violent (vs. nonviolent) video games would causally affect emotion recognition (H2a) and inhibitory control for emotional faces (H2b), and whether this effect would be moderated by age (H3), antisocial media exposure (RQ1), and habitual violent video game exposure (RQ2).

Method

Participants. Dutch adolescent boys participated in this experiment ($N = 161$; $M_{\text{age}} = 13.66$; $SD = 1.11$; age range 12–16 years). All participants and their parents gave active consent to participate in the study. The experiment has been approved by the Institutional Ethical Review Board.

Procedure and design. The experiment took place under similar conditions as in Study 1: participants were tested individually at a school laboratory. After obtaining participant's consent, the study started with the same questionnaire as in Study 1. Next, participants were randomly assigned to play either a violent ($n = 81$) or nonviolent ($n = 80$) game for 30 min (between-participants design). Immediately afterward, they answered manipulation check questions and continued with three computer tasks measuring emotion recognition, inhibitory control, and perspective taking (reported elsewhere), the same as in Study 1. After completing the 60-min procedure, they were debriefed and rewarded.

Materials

Measures. All measures, including habitual exposure to violent video games, antisocial content media exposure (Cronbach's alpha antisocial scale = .89), and three personality traits: trait empathy (Cronbach's alpha = .57), trait aggressiveness (Cronbach's alpha = .89), and trait sensation seeking (Cronbach's alpha = .90), were the same as in Study 1.

Video Game Manipulation. Participants were randomly assigned to play one of the four video games for 30 min, which is comparable to other studies using violent game manipulations on social outcomes and found significant effects after 25 min (Engelhardt et al., 2011) or 20 min of exposure (Konijn et al., 2007). In the violent game condition ($n = 81$), participants played a shooting game *Call of Duty: Black Ops II* (2012; PEGI 18+; $n = 42$) or a fighting game *Mortal Kombat* (2011; PEGI 18+; $n = 39$). In the nonviolent game condition ($n = 80$), participants played a racing game *Gran Turismo 5* (2010; PEGI 3+; $n = 38$) or a soccer game *FIFA 15* (2014; PEGI 3+; $n = 42$). See details in Supplementary Materials.

Video Games Experience Check. Participants answered six questions (Engelhardt, Mazurek, Hilgard, Rouder, & Bartholow, 2015) checking how they experienced the gameplay. See details in Supplementary Materials.

Computer tasks. The two dependent variables, emotion recognition and inhibitory control, were measured through the same computer tasks as described in Study 1: Facial Expressions Matching Test and emotional Stop Signal Task, respectively.

Analysis plan. After preliminary analyses including a manipulation check (*t*-test between the two game conditions), we tested hypotheses in (M) ANOVA.

Emotion recognition. Predictions regarding an effect of short-term violent gameplay (H2a), and its interactions with age (H3a), antisocial CME (RQ1a), and VVGE (RQ2a) were tested in ANOVA. Emotion recognition correctness was a dependent variable and game was a between-fixed factor (violent vs. non-violent). Age, antisocial CME, and VVGE were included as possible moderators of the game effect. Finally, trait empathy was included as a covariate.

Inhibitory control. Predictions regarding an effect of short-term violent gameplay (H2b) and its interactions with age (H3b), antisocial CME (RQ1b), and VVGE (RQ2b) were tested in MANOVA. SSRT average was a main dependent variable, and game was a between-fixed factor (violent vs. nonviolent). Age, antisocial CME, and VVGE were included as possible moderators of the game effect. Finally, trait physical aggressiveness was included as a covariate. Moreover, SSRT anger and SSRT disgust were explored as two dependent variables in Supplementary Materials based on the same analysis.

Results

Preliminary analyses. Descriptive statistics including all measures are presented in Table 1. See Tables S8–S10 for frequencies of (violent) video gaming and Table S11 for zero-order correlations.

Manipulation check. Results of a *t*-test showed that participants who played a violent video game in the laboratory perceived it as more violent ($M = 5.36$; $SD = 1.73$) than the group who played a nonviolent video game ($M = 1.6$; $SD = 0.48$; $t(156) = -14.79$; $p < .001$; $d = 2.34$), confirming that the video game manipulation worked according to expectations. Moreover, participants found playing a violent video game more challenging, more interesting, and more engaging as compared to playing a nonviolent game (Table S12).

Hypotheses testing. *Emotion recognition.* Results of the ANOVA showed no main effect of game on emotion recognition correctness ($p = .689$), failing to support H2a on short-term effects of violent video gameplay. Furthermore, no main effect of age was found ($p = .497$). Likewise, the covariates were not significant: habitual violent video game exposure ($p = .769$), antisocial CME ($p = .608$), and trait empathy ($p = .112$). No significant interaction effects were observed between game by age ($p = .983$), game by habitual violent video game exposure ($p = .886$), and game by antisocial CME ($p = .147$), thus not supporting H3 and RQ1. See detailed results in Table 4.

Inhibitory control. A MANOVA analysis showed no main effect of game on inhibitory control: $p = .945$, neither for disgusted faces ($p = .950$), nor for angry faces ($p = .759$), failing to support H2b about short-term effects of violent game exposure on inhibitory control. A main effect of age was found for overall SSRT ($p = .031$), reflecting a developmental effect: the older the adolescent participants, the better their inhibitory control (i.e., shorter SSRT). Furthermore, the effects of covariates were not found: habitual violent video game exposure ($p = .819$), antisocial CME ($p = .374$), and trait aggressiveness ($p = .260$). Finally, no interaction effects on inhibitory control were found for game by age ($p = .920$), game by habitual violent video game exposure ($p = .670$), and game by antisocial CME, $p = .854$ (RQ1). Detailed results are presented in Table 5. SSRT results for separate emotions (disgust and anger block) are included in Table S11.

Conclusion

Results of Study 2 did not support hypotheses regarding the causal effects of short-term exposure to a violent video game on accuracy of emotion recognition and inhibitory control over emotional faces. Moreover, neither age, nor habitual violent video game exposure or antisocial media exposure moderated the tested relationships. However, results indicated a developmental effect of age on inhibitory control, which is in line with Study 1.

TABLE 4
Results of the ANOVA Analysis for Emotion Recognition as Measured with the FEMT (Study 2; $N = 156$)

Effect	F*(1, 147)*	p	η^2
Game	0.16	.689	<.01
Age	0.47	.497	<.01
VVGE	0.09	.769	<.01
CME	0.26	.608	<.01
Empathy	2.56	.112	.02
Game × Age	<0.01	.983	<.01
Game × VVGE	0.02	.886	<.01
Game × CME	2.12	.147	.01

Note. CME = antisocial content media exposure; Empathy = trait empathy; VVGE = violent video game exposure.

TABLE 5
Results of the MANOVA Analysis for Overall SSRT as Measured with the emoSST (Study 2; *N* = 156)

	SSRT overall		
Effect	F*(2, 146)*	p	η^2
Game	0.06	.945	<.01
Age	3.54	.031	.05
VVGE	0.20	.819	<.01
CME	0.99	.374	.01
Aggression	1.36	.260	.02
Game × Age	0.08	.920	<.01
Game × VVGE	0.40	.670	.01
Game × CME	0.16	.854	<.01

Note. Aggression = trait physical aggressiveness; CME = antisocial content media exposure; VVGE = violent video game exposure.

GENERAL DISCUSSION

In two studies, correlational and experimental, we aimed to investigate the relationships and short-term effects, respectively, of exposure to violent video games on emotion recognition and inhibitory control in early adolescents. In addition, we explored the roles of age and exposure to general antisocial media content in the tested relationships. Results of the correlational Study 1 indicated that *not* specifically habitual exposure to violent video games (H1), but rather general exposure to antisocial content in all kinds of media (RQ1) was related to worse recognition of negative emotions. Both habitual exposure to violent games (H1) and antisocial content exposure (RQ1) predicted better inhibitory control for negative emotional facial expressions in others. Moreover, in the experimental Study 2, we observed no short-term effects of violent video gameplay on emotion recognition and inhibitory control (H2). Further, no interaction effects were found between age and habitual violent video game exposure, antisocial content media exposure, or a violent game manipulation (H3). Finally, no interaction effects were found between the effect of game manipulation (violent vs. nonviolent) and antisocial media content exposure (RQ1) or habitual exposure to violent video games (RQ2).

The finding that habitual exposure to violent video games was *not* negatively related to emotion recognition skills (Study 1) does not support our H1. While this is in line with the results on the relationship between action (violent) gaming and speed of emotion recognition (Pichon et al., 2020), it is not in line with the recent findings on the relationship between habitual violent gaming and lower accuracy of emotion recognition (Miedzobrodzka, Buczny, Konijn, & Krabbendam, 2021). Moreover, our finding that antisocial media content exposure was negatively related to accuracy of emotion recognition contributes to and further extends previous research on violent media exposure and speed of emotion recognition (Kirsh et al., 2006). A possible explanation for such mismatch in our findings could be that violent video games are not the only source of antisocial media content. Our results suggests that exposure to antisocial content in all sorts of media (*not* specifically in video games) predicts worse emotion recognition. Finally, our results contribute to earlier findings, since the effect of antisocial media content could be generalized to various negative emotions, not only disgust (Diaz et al., 2016).

Furthermore, our findings showed *better* inhibitory control over emotional stimuli related to higher exposure to violent video games and antisocial media exposure (Study 1). This is not in line with earlier research indicating that exposure to violent video games (violent media) was related to *decreased* inhibitory control skills in adolescents (Hummer et al., 2010; Kronenberger et al., 2005) and to greater emotional distraction during inhibitory processes (Kalnin et al., 2011; Wang et al., 2009). However, our findings from Study 1 are in line with the outcomes of Stockdale et al. (2015), Stockdale et al. (2017) who also found more efficient inhibitory control related to habitual violent video game exposure and as a result of watching a violent movie, but in adult samples. A possible mechanism explaining our results for inhibitory control is desensitization to negative emotional stimuli related to habitual violent video game exposure and exposure to antisocial media content (Carnagey et al., 2007), which would also be in line with our findings for emotion recognition. It seems that at the cost of lower sensitivity to emotional faces, exposure to antisocial media content in general (not necessarily to violent video games) could make adolescents less distracted by the emotional stimuli and more efficient in inhibitory control in the emotional Stop Signal Task. This aligns with earlier research involving different cognitive tasks with emotional stimuli (Bailey & West, 2013; Bailey, West, & Anderson, 2010; Stockdale et al., 2015, 2017), which we could now show for adolescents.

Our contrasting findings with *decreased* inhibitory control skills in adolescents (Hummer et al., 2010; Kronenberger et al., 2005) may be further explained by differences with previous research in measurement of inhibitory control, use of emotional stimuli, and different age groups. First, other studies used different measures of inhibitory control: Stroop task (Bailey et al., 2010; Kronenberger et al., 2005) or go/no-go task (Hummer et al., 2010), while we used the Stop Signal Task, which is a more precise measure of response inhibition (cf. Cohen & Lieberman, 2010). Second, in contrast to negative words in the Stroop task, where the participant's task is to name the color of the ink (Wang et al., 2009; Kalnin et al., 2011), we used the Stop Signal Task with negative emotional faces, similarly as Stockdale et al. (2015), Stockdale et al. (2017). People process negative words differently than negative emotional faces (Bayer & Schacht, 2014). Third, we tested early-late adolescents (aged 12–17), while previous research relating violent media/game exposure to inhibitory control included late adolescents and young adults. Given developmental improvements in inhibitory control over emotional stimuli (Cohen-Gilbert & Thomas, 2013), habitual and short-term violent gaming may have differently affected our younger players than the older players in previous research.

Our findings mainly contribute to the growing body of literature on how violent video games may affect adolescents. The results point to the role of habitual exposure to violent video games in explaining changes in inhibitory control over emotional faces. However, they also indicated that habitual exposure to antisocial media content in general (which was *not* specific to violent video games) explained changes in accuracy of emotion. Thus, our results are in line with the violent media desensitization model (Carnagey et al., 2007), predicting that habitual exposure to violent media content leads to lower sensitivity to emotional stimuli, which could contribute to more efficient inhibitory control over emotional faces. However, since the observed relationships in Study 1 were only correlational, and we have not found a significant effect of the violent game experiment in Study 2, we cannot claim causality of the observed associations and we cannot exclude an alternative explanation for Study 1. Participants who showed difficulties with emotion recognition were also more often exposed to antisocial media content in general, and participants who exhibited a stronger ability to inhibit their reactions to negative emotional faces have been exposed more often to violent content in video games and antisocial content in other media. Future studies could further investigate the effects of violent video games on adolescents to clarify the direction of these observations and explore the possible impact on adolescent development from a longitudinal perspective.

Findings of age-related differences in inhibitory control in the current studies contribute to the developmental literature. Our results are in line with the research showing developmental changes in emotion recognition (Thomas et al., 2007) and in inhibition (Cohen-Gilbert & Thomas, 2013; Fosco et al., 2019), which may be further connected to the broader research on risk taking in adolescence (Blakemore & Robbins, 2012). Finally, our results indicated that negative emotions may disrupt inhibitory control by consuming attentional resources in normally developing adolescents (Farbiash & Berger, 2016).

LIMITATIONS AND FUTURE DIRECTIONS

Our studies have several limitations. Although the emotion recognition measurement through the Facial Expressions Matching Task and inhibitory control with the emotional Stop Signal Task are validated measures (Szczygieł et al., 2012; Verbruggen & Logan, 2008), they do not allow to analyze correctness of recognition for different emotions *separately*, or inhibitory control for emotional vs. neutral faces. This limits comparisons with other studies, which measured emotion recognition of emotions separately for each emotion (cf., Kirsh et al., 2006; Diaz et al., 2016).

Furthermore, despite guidelines how to best measure habitual violent video game exposure (Busching et al., 2015), this measurement is used quite flexibly across different studies, making comparison with our results for habitual violent gaming measure more difficult. In the current work, we followed Anderson and Dill (2000) measuring general violent gaming frequencies based on a 5-point scale, whereas other work asked for the amount of daily hours spent on violent gameplay in the past month (Miedzobrodzka et al., 2021). Differences in measurement likely contributed to different outcomes. Therefore, future studies should measure frequencies of gaming based on direct estimates (e.g., hours per day or per week; Fikkers, Piotrowski, & Valkenburg, 2016), or telemetry data (Johannes, Vuorre, & Przybylski, 2021). Moreover, in the current studies, we measured and compared both subjective (Anderson & Dill, 2000) and objective violence ratings (based on PEGI), which showed that subjective violence ratings were underestimated (see Supplementary Materials). Therefore, we used only the objective ratings in our analyses. Therefore, we suggest that future studies should measure habitual violent video game exposure based on objective violence ratings to enable a better standardization of video game content ratings.

Some limitations related to the experimental Study 2 could explain the lack of significant short-term effects of playing violent video games. The manipulation check indicated that, besides the expected difference in perceived game violence, playing a violent video game was more challenging, interesting, and engaging as compared to playing a nonviolent game. These between-game differences might have influenced the expected violent video game manipulation effect. Future studies could limit the differences in the games used for a manipulation by editing one game into a violent and nonviolent condition (cf. Gentile, Swing, Anderson, Rinker, & Thomas, 2016) or to pretest different video games in adolescent samples (Konijn et al., 2007).

A possible alternative explanation for a lack of effects of experimental manipulation in Study 2 could be the duration of violent gameplay. However, 30-min exposure in our experiment was comparable with other studies that found significant-effects violent gameplay (cf., Engelhardt et al., 2011; Konijn et al., 2007). Based on that, the duration of the exposure should not explain the lack of effects. We suggest that future meta-analyses on violent video games should use time of (experimental) violent game exposure as a possible moderator to recommend how long such manipulation should last to observe an expected effect.

Moreover, despite a sufficiently large sample size for this experiment, video game conditions were not counterbalanced in terms of habitual violent video game exposure level. In fact, participants who played a violent game in the experiment only had a slightly higher habitual exposure level than participants who played a nonviolent game. Future studies could preselect participants with high vs. low habitual violent video game exposure levels based on a larger sample (cf., Engelhardt et al., 2011; $N = 2000$, university students).

Finally, our findings cannot be generalized to female samples, since we only tested male participants. We focused on adolescent boys only due to gender-related developmental changes in emotion recognition (Lee et al., 2013) and inhibitory control (Tottenham et al., 2011). However, it would be interesting to look at developmental gender differences related to violent media exposure in future studies.

CONCLUSION

Our correlational Study 1 indicated that *not* habitual exposure violent video games, but exposure to antisocial content in all sorts of media was related to less accurate recognition of negative emotional faces, which only partially confirmed our expectations.

Interestingly, both habitual exposure to violent video games and antisocial media content were related to *better* inhibitory control over emotional stimuli. We applied the violent media desensitization model to explain these findings. Frequent exposure to antisocial media content (beyond violent video games) may make adolescents insensitive to emotional stimuli which in turn could help young players to *not* be distracted by emotional content and better perform in the inhibitory control task. However, causal directions of these relationships were not found in the experimental Study 2. Thus, our results do not indicate that violent video games may have a negative impact on young gamers. Future research in adolescents may further investigate cognitive and emotional processes, which may be affected by exposure to antisocial media content. While effects of such exposure may be beneficial in a game environment, they may be less desired for social and cognitive development. Since both of our studies showed that inhibitory control improves with age, it seems important to further study developmental trajectories of this skill in the antisocial media exposure context.

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Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Supplementary Material