Computers in Human Behavior 70 (2017) 39–43

Contents lists available at ScienceDirect

Computers in Human Behavior

journal homepage: www.elsevier.com/locate/comphumbeh

Full length article

Violent video game effects on salivary cortisol, arousal, and aggressive thoughts in children

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ARTICLE INFO

Article history:
Received 27 September 2016
Accepted 19 December 2016
Available online 21 December 2016

Keywords:
Media violence
Violent video games
Cortisol
Aggressive cognition

ABSTRACT

An experiment investigated the effects of violent content in video games on two physiological indicators of the fight-or-flight response (cortisol and cardiovascular changes) and on accessibility of aggressive thoughts in children. Participants played a randomly assigned violent or nonviolent video game, rated the game on several dimensions, and did a word completion task. Results showed that the violent video game increased cortisol and (for boys) cardiovascular arousal (relative to baseline) more than did the equally exciting nonviolent game. The violent game also increased the accessibility of aggressive thoughts. The cortisol findings in particular suggest that playing a violent video game may activate the sympathetic nervous system and elicit a fight-or-flight type response in children. Theoretical implications and future research are discussed.

Researchers have suggested that violent media exposure is one of many risk factors associated with aggression and violence (Anderson, Gentile, & Buckley, 2007; Anderson et al., 2003; DeLisi, Vaughn, Gentile, Anderson, & Shook, 2012; Gentile, 2003; Krahé, 2013; Strasburger, Wilson, & Jordan, 2009). Multiple narrative and meta-analytic literature reviews have found that violent video game exposure is positively related to aggressive feelings, aggressive thoughts, aggressive behavior, and physiological arousal (e.g., Anderson & Bushman, 2001; Anderson et al., 2010; Dill, 2009, 2013; Ferguson, 2007; Kirsh, 2012; Singer & Singer, 2012; Strasburger et al., 2009; Warburton & Burstein, 2012). Given the widespread popularity of video games among children and the large proportion of waking hours spent on them, careful scientific studies on the effects of such games are important for practical as well as theoretical reasons.

Empirical support for the link between media violence and aggression has been found for many types of media (for a comprehensive review, see Anderson et al., 2003). These include violent movies (e.g., Bushman, 1995), violent television (e.g., Huesmann, Moise-Titus, Podolski, & Eron, 2003), violent song lyrics (e.g., Anderson, Carnagey, & Eubanks, 2003), violent comic books (e.g., Kirsh & Olczak, 2002), and violent video games (VVG) (e.g., Anderson et al., 2007). The effects of violent media have been studied with males and females, children, adolescents, and young adults, and both Western (e.g., Germany: Krahé, Busching, & Möller, 2012) and Eastern cultures (e.g., Japan: Anderson et al., 2008). Generally, the effects appear remarkably similar across gender, culture, and age, though occasionally there has been evidence of moderator effects. For example, a meta-analysis by Bushman and Huesmann (2006) found that short-term effects of media violence on aggressive behavior tended to be slightly stronger on adults than on children, whereas long-term effects showed the opposite pattern.

The link between VVG play and physically aggressive behavior is by far the most well-investigated within the field. In the most comprehensive meta-analysis published to date, Anderson et al. (2010) identified 140 individual effect sizes with a total of over 68,000 participants. They also found sufficient studies of each major design type (experimental, cross-sectional, and longitudinal), and of various ages, genders, and cultures to yield fairly sensitive tests of these moderators.

However, there are considerably fewer video game studies of some other key aggression-theory related outcomes. A careful review reveals three important gaps that are in need of additional research, each involving a paucity of experimental studies with child participants. First, to date, only two studies have examined the effects of playing a violent video game (versus a nonviolent

Abbreviations: SNS, Sympathetic Nervous System; VVG, violent video games.

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http://dx.doi.org/10.1016/j.chb.2016.12.045

game) on the stress hormone cortisol in children (Ivarsson, Anderson, Åkerstedt, & Lindblad, 2009a; Maass, Lohaus, & Wolf, 2010). These two studies produced contradictory results, thus highlighting the question of whether there exists a link between VVG play and cortisol release in children. Second, although seven studies (8 effects) experimentally examined the effect of violent video games on cardiovascular measures of arousal using child participants, only one meets the "best practices" criteria of Anderson et al., 2010 (i.e., Fleming & Rickwood, 2001). Third, only one "best practices" experimental study with child participants has examined the VVG effect on measures of aggressive cognition (Kirsh, 1998).

Research addressing the first two gaps is important because of the potential link between violent video game play and sympathetic nervous system (SNS) activation of the fight-or-flight response system. Activation of the SNS can be indexed by both cardiovascular measures and, perhaps more precisely, by release of the stress hormone cortisol. Regarding the third gap, the major social-cognitive theories of media violence on aggressive behavior predict that brief VVG exposure will increase the accessibility of aggressive thoughts in the short-term, and that repeated priming can result in long-term effects (e.g., Anderson et al., 2003, 2007; Huesmann, 1986; Möller & Krahé, 2009). Thus, investigating the potential link between VVG play and aggressive thoughts, employing adequate experimental setups, remains a theoretically important endeavor. The present study addresses all three of these gaps in a sample of young children.

1. Salivary cortisol and fight-or-flight

Cortisol is a hormone that is released by the adrenal gland and is a physiological indicator of activation of the sympathetic nervous system, especially the fight-or-flight response (Gunnar, Bruce, & Donzella, 2001; Kirschbaum & Hellhammer, 1989; 1994). Cortisol is an indicator of stress and fight-or-flight responding, and both behavioral (e.g., exercise; Stahl & Dorner, 1982) and psychological stressors (e.g., being scared; Kirschbaum & Hellhammer, 1989) have the ability to release cortisol throughout the body. Mason (1968) argued that psychological stressors are one of the most powerful stimuli to influence the release of cortisol into the body.

Kirschbaum and Hellhammer (1989; 1994) suggest two criteria a stressor should have in order to influence the release of cortisol. There needs to be some degree of emotional ego involvement in the stimulus, and the psychological stressor must be related to a suspenseful anticipation of events (Hellhammer, Rottger, Lorenzen, & Hubert, 1986). Clearly, violent media can meet both of these criteria. Indeed, Maass et al. (2010) randomly assigned 98 boys to (a) view a non-violent television program (Who wants to be a Millionaire), (b) view a violent television program (King Kong), (c) play a non-violent video game (Who wants to be a Millionaire Junior Edition), or (d) play a violent video game (King Kong) and measured cortisol (amongst other outcomes) after 22.5 min and 45 min of interacting with their respective media. Results showed a significant main effect of content, such that higher cortisol was observed for the violent stimuli compared to the non-violent stimuli. In contrast, another study employing a repeated measures design also compared the effects of a violent game (Manhunt) to the effects of a nonviolent game (Animaniacs) on cortisol secretion in children (Ivarsson et al., 2009a). This study found no difference in cortisol release between the two testing conditions. Thus, whether or not VVG play has an impact on salivary cortisol levels in children remains an open question. The issue, however, has implications for the study of aggression. If violent media engage the physiological fight-or-flight system, such engagement could be one mechanism by which violent media increase the likelihood of aggressive behavior, given that research has shown significant positive correlations between cortisol and aggression (e.g., Peckins, Dockray, Eckenrode, Heaton, & Susman, 2012; van Bokhoven et al., 2005).

Research has shown that gender may moderate the cortisol effect (Kirschbaum, Wust, & Hellhammer, 1992; Kudielka & Kirschbaum, 2005), and that cortisol levels are highest in the morning, relative to later in the afternoon (Kirschbaum & Hellhammer, 1989; Rehman, Brismar, Holmback, Akerstedt, & Axelsson, 2010). Therefore, gender and time of day were controlled in the current experiment.

1.1. Overview of the present research

Child participants were randomly assigned to play either a violent or a nonviolent video game (all games were age-appropriate according to contemporary standards). Baseline measures of cardiovascular activity and cortisol were gathered and used as covariates in analyses of physiological stress induced by the game play. After playing the game, children filled out rating forms and completed a standard word task designed to measure accessibility of aggressive thoughts. If playing a violent video game activates the fight-or-flight system in children, then we should see higher levels of cortisol in the violent game conditions than in the nonviolent game conditions. Similarly, if violent content primes aggressive thinking in children, then the experimental manipulation should similarly affect accessibility of aggressive thoughts.

2. Method

2.1. Participants

One hundred and thirty-six children (67 male, 67 female, 2 unmarked) participated in the current study. The average age of the sample was 10.1 ($SD = 1.25$, Range = 8 to 12) years old. The sample was recruited by flyers sent home through schools and by advertising in newspapers. The majority of the sample was Caucasian (77.9%), which is representative of the region. The study was IRB approved and all participants were treated in accordance with APA ethical guidelines.

2.2. Materials

2.2.1. Video games and equipment

Several E-rated (appropriate for Everyone according to the ESRB) games were tested for possible use in this study during a pilot setup using an unrelated sample of children. The two games that were rated as having the most and the least violence were selected. *Spiderman* for the Xbox was the violent video game. This game involves controlling the character in fights with gunmen who are shooting at him. The nonviolent game was *Finding Nemo* for the Xbox. In this game, players control Marlin (Nemo's father) through the ocean to find Nemo. Only 21 (33.3%) of participants in the violent condition and 15 (20.5%) participants in the nonviolent condition reported having previously played their assigned game.

2.2.2. Video game ratings

After playing their assigned game, participants rated whether the game was exciting, frustrating, fun, boring, violent, and difficult on a 1 (*strongly disagree*) to 7 (*strongly agree*) Likert scale (Anderson & Dill, 2000).

2.2.3. Physiological responding

Cardiovascular arousal was assessed by measuring heart rate and mean arterial pressure with a Datascope Accutorr 4 hospital blood pressure monitor. A cardiovascular arousal composite variable was calculated by transforming heart rate and mean arterial pressure scores into z-scores and summing them. We aggregated the heart rate and mean arterial pressure scores because both are conceptualized to be SNS arousal indicators.

Cortisol samples are typically collected via saliva samples or blood samples. However, collecting blood samples raises both practical and ethical concerns, especially with children (Kirschbaum & Hellhammer, 1989). For example, the stress of knowing that one will have to give blood samples can itself increase cortisol. Research comparing these two methods of assessing cortisol has found a significant degree of agreement between the two methods (*r*s between 0.54 and 0.97; e.g., Ferguson, Price, & Wallace, 1980). Therefore, the current study used salivary cortisol samples.

Studies that have sampled salivary cortisol have found that the time latency to reveal a mild psychological stressor effect is approximately 15–20 min (Kirschbaum, Steyer, Eid, Patalla, Schwenkmezger, & Hellhammer, 1990; Kudielka, Buske-Kirschbaum, Hellhammer, & Krischbaum, 2004). Thus, even after participants are stressed, it will take approximately 20 min for the increase in cortisol to be detectable in the saliva.

To measure salivary cortisol, participants were given a piece of Trident original gum to chew in order to help supply a viable amount of saliva, which was collected in a vial. Trident gum was appropriate to use because the original formula for this gun did not contain any chemicals or substances that would affect cortisol levels. Home saliva kits were given to the participants' parents. Specific instructions concerning how to use the vials, how to store the vials, and how to send the vials to the lab were included. The instructions asked parents to collect the samples of spit at the same time of day that their children had been in the lab on a "normal" day without atypical stressors.

2.2.4. Word completion task

To measure accessibility of aggressive cognitions, we used a modified version of the Word Completion Task (Anderson, Carnagey, et al., 2003). This questionnaire has participants fill in letters in blanks to complete a word. For instance, the fragment "K I _ _" could be completed aggressively (e.g., "KILL") or non-aggressively (e.g., "KISS"). Sixty-two word fragments were used; the major modification from the original version involved using a simplified and shortened list. The standard approach to scoring was used in which aggressive thought ratio was created by dividing the number of aggressive word completions by the total number of fragments completed. Higher scores indicate greater accessibility of aggressive thoughts. In the present study, this measure showed acceptable reliability ($\alpha = 0.81$).

2.3. Procedure

After greeting parents and children, the Experimenter gave initial instructions about the study, the informed consent (for the parent) and the assent (for the child) forms. Once these forms were read and signed, child participants were individually seated in a room with a computer. Heart rate and mean arterial pressure were measured. Participants provided the first saliva sample and had their heart rate and mean arterial pressure measured a second time. These procedures took about 10–15 min. Because coming to a laboratory for a study may be stressful, and because elevated cortisol levels show up in saliva samples about 20 min after the stressor, the initial saliva sample was used only as a means of training the children how to do this assessment, and was not used as the baseline cortisol measurement. But, because cardiovascular measures return to normal fairly quickly, these first two measurements of heart rate and mean arterial pressure were combined and used as the baseline measure of cardiovascular arousal.

Participants were randomly assigned to play one of the two video games for 25 min. They were given brief instructions on how to play their assigned game and were then allowed to play. During that 25-min video game play period, participants had their heart rate and mean arterial pressure measured three times (at 3 min, 10 min, and 20 min) during game play. These three measurements were combined to create a measure of cardiovascular arousal during game play.

After the game play, the experimenter obtained a second saliva sample. Next, participants rated the video game on the six 7-point scales described earlier. Post-game mean arterial pressure and heart rate were then measured. Participants completed the Word Completion Task, which lasted five minutes. After another brief filler task, the participants provided a third saliva sample, were thanked and fully debriefed, and were given a home saliva kit. The second and third measurements of cortisol were averaged to create a more stable indication of stress level during game play.

Parents were instructed how to collect the saliva, and to collect it on three different "normal" days at the same time of day that they had been in the lab. This was done to control for time of day and to get a better baseline sample in a stress-free setting. Parents also filled out a data sheet with the home kit documenting when they collected the samples, and whether their children were sick on those days. Inspection of the sheets suggested general compliance with instructions. These home assessments were used as the cortisol baseline measure.

3. Results

3.1. Preliminary analyses

3.1.1. Interrelations among variables

For both cardiovascular arousal and cortisol, the baseline and during game play measures were significantly correlated ($r = 0.55$, $p < 0.01$ for cardiovascular arousal, $r = 0.45$, $p < 0.01$ for cortisol). Post-play aggressive cognition was significantly related to cardiovascular arousal after video game play ($r = 0.24$, $p < 0.05$). See Table 1 for an overview of all correlations.

3.1.2. Video game ratings

A principal components factor analysis with a Varimax rotation was used to reduce the number of items on the post-experimental video game rating sheet. As in previous studies, two factors emerged accounting for 72.2% of the total variance. The Exciting

Table 1
Correlations between measures for experiment 2.

	VG	CR1	CR2	CVG	Chome	AT	Sex	Frust
VG	–							
CR1	−0.02	–						
CR2	0.13	0.55^{**}	–					
CVG	0.20^{*}	−0.14	−0.12	–				
Chome	−0.03	0.03	−0.09	0.45^{**}	–			
AT	0.23^{**}	0.08	0.24^{**}	−0.08	−0.02	–		
Sex	0.02	-0.22^{**}	−0.06	0.07	−0.11	0.07	–	
Frust	-0.20^{*}	0.06	0.02	−0.02	0.08	0.02	-0.18^{*}	–

VG = video game content (non-violent = −1, violent = 1), CR1 = baseline cardiovascular arousal, CR2 = cardiovascular arousal during game play, CVG = cortisol during video game play (average Time 2 and Time 3), Chome = cortisol at home, AT = Aggressive Thoughts, SEX = sex of participants (male = 1, female = −1), Frust = Frustrated factor scores.
$^{**}p < 0.01$, $^{*}p < 0.05$.

Factor contained the items *entertaining, fun,* and *boring* (reverse coded). Video game did not significantly affect this factor, $F(1, 131) = 2.45$, $p > 0.10$, suggesting that the two games were equivalent in how exciting they were. The Frustrating Factor contained the items *frustrating* and *difficult*. An ANOVA showed a significant main effect of video game on the Frustrating Factor, $F(1,133) = 5.52$, $p < 0.03$, *partial* $\eta^2 = 0.04$. The nonviolent video game (M = 3.81, SD = 1.47) was rated significantly more frustrating than the violent video game (M = 3.19, SD = 1.65). Thus, this factor was used as a covariate in subsequent analyses. Note that if frustration affects the dependent variables, this difference actually works against the hypotheses. Finally, the violent video game (M = 3.87, SD = 1.95) was rated as more violent, $F(1, 131) = 98.42$, $p < 0.001$, *partial* $\eta^2 = 0.43$ than the nonviolent video game (M = 1.30, SD = 0.90). This served as a manipulation check.

3.2. Main analyses[1]

3.2.1. Cortisol

A one-way ANCOVA was conducted with video game as the independent variable, cortisol during game play as the dependent variable, and scores on the Frustrating Factor and baseline cortisol (home sample) as covariates. Baseline level of cortisol was a significant covariate, $F(1, 94) = 26.07$, $p < 0.001$, *partial* $\eta^2 = 0.22$. The Frustrating Factor was not significant, $F(1, 94) = 0.61$, $p > 0.05$, *partial* $\eta^2 = 0.007$. Most important was the significant main effect of game, $F(1, 94) = 8.78$, $p < 0.01$, *partial* $\eta^2 = 0.09$. Children in the violent game condition had higher cortisol levels during game play ($M = 0.167$) than children in the nonviolent condition ($M = 0.112$), thus confirming the SNS activation hypothesis.

3.2.2. Cardiovascular arousal

A two (video game) X two (sex) ANCOVA yielded a large effect of the baseline measure, $F(1, 112) = 64.38$, $p < 0.001$, *partial* $\eta^2 = 0.57$. The Frustrating Factor was not significant, $F(1, 112) = 0.37$, $p > 0.05$, *partial* $\eta^2 = 0.003$. There was a significant main effect of video game, $F(1, 112) = 4.76$, $p < 0.05$, *partial* $\eta^2 = 0.04$, and a game X sex interaction, $F(1, 112) = 10.16$, $p < 0.01$, *partial* $\eta^2 = 0.09$. Basically, the violent video game increased arousal (after controlling for baseline) for boys (adjusted $M_{Spiderman} = 0.70$, $M_{Nemo} = -0.51$) but not girls (adjusted $M_{Spiderman,} = -0.25$, $M_{Nemo} = -0.03$).

3.2.3. Aggressive thoughts

A one-way ANCOVA on the aggressive thoughts ratio showed a significant main effect of video game, $F(1,130) = 7.57$, $p < 0.01$, *partial* $\eta^2 = 0.06$. Aggressive thoughts were more accessible after participants played the violent (M = 0.204) rather than nonviolent (M = 0.172) video game. This replicates VVG effects found with older participants. The Frustrating Factor was not significant, $F(1, 130) = 0.61$, $p > 0.05$, *partial* $\eta^2 = 0.005$.

4. Discussion

Playing a violent video game led to more aggressive thoughts being activated in semantic memory and to greater cortisol levels during game play for elementary school children, relative to playing an equally exciting but nonviolent game. These effects occurred even when frustration with the game was controlled. The cortisol results suggest that for children, violent video game play can activate the sympathetic nervous system and fight-or-flight responding, resulting in increased stress hormone release. The VVG effect on accessibility of aggressive thoughts was also clear, and is theoretically important because it is only the second known experimental test of this hypothesis to use children and to meet best practices criteria outlined in Anderson et al. (2010).

The main purpose of this research was to fill in gaps in the existing literature on violent video game effects on children. As previous research has produced inconsistent results, our primary interest in the present study was the experimental test of whether VVG play would lead to increased cortisol release in children when compared to playing an equally exciting, nonviolent game.

4.1. Combining cortisol and aggressive thinking

Psychophysiological studies have documented that the SNS is activated and cortisol is released under conditions of stress, which indicates that the fight-or-flight response has been triggered. Scary or violent stimuli have the ability to increase salivary cortisol levels, especially when the stimuli are relatively novel. In the present study, and despite knowing that the violence in the game was not "real," that it was "just a game," the violent play still triggered a fight-or-flight type response. Knowing that it is not real may not matter to one's amygdala, which helps coordinate bodily preparation for survival. It is also likely that this activation of physiological arousal systems is part of the "rush" that players report from playing violent games, although this hypothesis has yet to be tested directly.

This finding adds to the theoretical understanding about the variety of mechanisms underlying how violent video games have short-term effects increasing the likelihood of aggression. Specifically, if a child is playing a violent video game, then the SNS will likely be activated. Coupled with an increased activation of aggression-related thoughts from violent video game exposure, the fight response of the nervous system may be activated, thus leading to a higher probability of behaving aggressively if provoked.

The finding that VVG play increased cardiovascular arousal for boys but not for girls calls for replication in future studies. Previous research has produced somewhat unclear results. For example, although some studies show that playing VVGs (compared to playing nonviolent games) affects heart rate variability (Ivarsson, Anderson, Åkerstedt, & Lindblad, 2009b), others show that VVG play is associated with increased heart rate but does not affect heart rate variability (Ivarsson, Anderson, Åkerstedt, & Lindblad, 2013). It is important to note that the studies by Ivarsson and colleagues were conducted with samples consisting exclusively of boys. Other research, including both boys and girls, has shown an increase in heart rate following video game play depicting realistic violence. However, the same study found that playing a video game containing unrealistic violence did not have a significantly different impact on heart rate than playing a nonviolent game (Barlett & Rodeheffer, 2009). Finally, Fleming and Rickwood (2001) showed that both boys and girls experience an increase in heart rate after playing a violent video game. Clearly, the exact effects of VVG play on cardiovascular arousal in boys and girls require further investigation. Also, considering current theoretical conceptualizations (e.g., Beauchaine, 2001), as well as the correlation found in this study between post-play aggressive cognition and cardiovascular arousal, it is worth noting that a better understanding of VVG effects on cardiovascular activation may be theoretically important to our comprehension of how violence in video games relates to aggression.

The current study has limitations that should be addressed in future research. The current research did not measure aggressive behavior. Although the VVG effects on cortisol and on aggressive

[1] Sex of participant had no impact on aggressive thoughts or cortisol, and so was dropped from statistical models from these variables to maximize sample size. Note that sample size varied because of missing data for some variables. This was especially true for cortisol. Missing data were unrelated to experimental condition.

thinking are interesting in their own right, it would be useful in future research to devise a paradigm that included an aggressive behavior measure to see if the levels of cortisol after violent video game play partially mediate the relation between violent video game play and aggressive behavior.

Funding source

No external funding was secured for this study.

Financial disclosure

The authors have no financial relationships relevant to this article to disclose.

Conflict of interest

The authors have no conflicts of interest to report.

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