

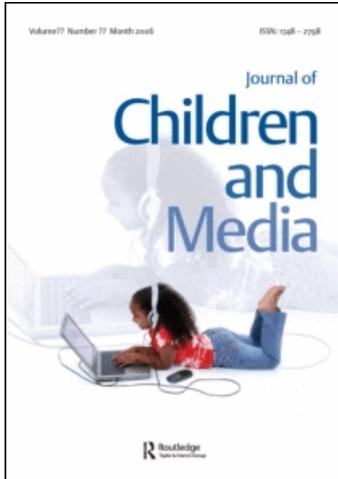
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MEDIA AND STRESS IN ADOLESCENT BOYS IN GERMANY

Psychophysiological effects of violent and nonviolent television programs and video games

Asja Maass, Arnold Lohaus and Oliver T. Wolf

The study is on the effects of entertainment media on physiological and psychological indicators of stress. The concept of stress is considered to play a key role in the explanation of the effects of media use on aggression, academic performance, and health. Two types of media (television and video games) and violent versus nonviolent content were compared. Differential effects on physiological measures (heart rate [HR], heart rate variability [HRV], cortisol, salivary alpha-amylase [sAA]) and subjective experience were expected. Study participants consisted of 98 boys, aged 11 to 14. Physiological stress reactions were higher for video games than for television with regards to HR and HRV. Violent content had greater effects on physiological stress than nonviolent content, when measured in terms of sAA, cortisol, and HRV. Violent content, in general, was rated as being more stressful but also more enjoyable. The results underline that certain types of media use are associated with subjective and physiological indices of stress.

KEYWORDS adolescent boys; alpha-amylase; cortisol; heart rate; heart rate variability; stress; television; video games; violence

Introduction

The present study focuses on media-induced, short-term physiological stress reactions and subjective experience. The concept of stress can be seen as a key component of the research concerning the impacts of media on the user. Stress can be connected to different approaches detailing the impact of media use. To a certain degree, stress can explain, clarify, and elucidate the mechanisms of media effects by serving as a moderating or mediating variable as described below.

Media Use and Aggression

One branch of research studies the impact of violent media content on aggression. The General Aggression Model (GAM), described by Anderson and Bushman (2002; see also Bushman & Anderson, 2002), offers a theoretical explanation for the often-documented association between exposure to violent media content and enhancement of aggressive thoughts, feelings, and behavior (e.g. Anderson & Bushman, 2001; Anderson & Dill, 2000;

Gentile, Lynch, Linder, & Walsh, 2004; Huesman & Eron, 1986; Slater, Henry, Swaim, & Anderson, 2003). The authors assume that behavior is based on two kinds of input variables: the person and the situation. A situational variable might be an instance of violent media content; the variables that are related to the person are affect (induced by the situation), cognition (e.g. activation of aggressive scripts), and arousal. These affect the individual's appraisal of the situation and the resulting behavior. The concept arousal is particularly important for the present study. Arousal can be seen as part of the physiological stress reaction: the activation of the SAMS (sympathetic adrenal medullary system¹) and its corresponding bodily processes (e.g. changing cardiovascular activity). Arousal can be expected to increase aggressive behavior (Carnagey & Anderson, 2003). Media-induced stress might have a moderating effect on the impact of violent content on aggressive behavior patterns: the degree of stress might determine the level of aggression.

Media Use and Academic Achievement

A second branch of research examines the relationships between media use and academic achievement. Several studies confirm a negative correlation between the time spent with media and academic or cognitive performance, independent of social background and general cognitive abilities (e.g. Borzekowski & Robinson, 2005; Gentile et al., 2004; Hancox, Milne, & Poulton, 2005; Ridley-Johnson, Cooper, & Chance, 1982; Zimmermann & Christakis, 2005). Media use is assumed to displace activities such as reading, doing homework, and learning, which are beneficial for academic achievements (e.g. Gadberry, 1980; Shin, 2004).

Furthermore, stress (such as that caused by media use) and the corresponding physiological reactions can influence cognitive and learning processes. The release of stress-related hormones and neurotransmitters improves the learning of emotional materials, but, conversely, impairs memory consolidation of neutral learning materials, working memory and memory retrieval (Cahill & McGaugh, 1996; Roozendaal, Okuda, de Quervain, & McGaugh, 2006; Wolf, 2008). The implication being that exposure to emotional and stressful content, such as media violence, might impair the consolidation of previous learned neutral contents, such as academic subject material in school. Therefore, short-term media-induced stress might serve as a mediator between media use and cognitive performance.

Media Use and Well-being

A third branch of research refers to the relationship between media use and physiological and psychological well-being. Several studies found an association between the duration of media use and physical factors such as obesity and inactivity (e.g. Andersen, Crespo, Bartlett, Cheskin, & Pratt, 1998; Armstrong, Sallis, Alcaraz, Kolody, & McKenzie, 1998; Gortmarker et al., 1996; Vandewater, Shim, & Caplovitz, 2004). These findings indicate that excessive media use can have negative effects on health. Some media use (especially the exposure to certain emotionally arousing contents such as violence) can be expected to cause physiological stress reactions. This implies a similar correlation between media use and further harmful effects on physiological and psychological well-being. For example, research yields evidence for an association between repeated exposure to stress and

diabetes as well as depression (Lehman, Rodin, McEwen, & Brinton, 1991; McEwen, 1998; Pollard & Ice, 2007).

Previous explanations suggest that media-induced stress might play a central role in the understanding and exploration of effects of media on different outcome variables. Stress might serve as a moderator (in terms of media-induced aggression) or mediator (in terms of effects on well-being and academic performance). An analysis of stress may, therefore, contribute to a better and deeper understanding of the broader effect of media on users. At this point two questions arise: whether media use does, in fact, induce stress and whether the use of different types of media featuring violent versus nonviolent content elicits different responses.

Stress and Media Use

"Stress ... is the nonspecific response of the body to any demand made upon it" (Selye, 1980, p. 78). It is an internal response to stimuli that challenges an individual. When analyzing bodily stress reactions, two different biological systems must be distinguished: the SAMS and the HPA (hypothalamic pituitary adrenal cortex axis²). SAMS-activation causes changes in cardiovascular activity by affecting the secretion of catecholamines (epinephrine and norepinephrine; Brown, 2007). Since direct analysis of catecholamines requires invasive measurement, alternatively the saliva enzyme alpha-amylase (sAA³) can be utilized for measurement purposes, as its increase correlates with an increase in catecholamines (Rohleder, Nater, Wolf, Ehlert, & Kirschbaum, 2004; van Stegeren, Rohleder, Everaerd, & Wolf, 2006). Stress-related activation of SAMS leads to an increase in heart rate (HR) and a decrease in heart rate variability (HRV; Appelhans & Luecken, 2006). HRV is the variation of the lengths of interbeat intervals (R-R intervals). It can be seen as an expression of the regulation and adaptation processes of the human body and is reduced under stress (Delaney & Brodie, 2000). In terms of HR, it should be noted that the emergence of a new stimulus often initiates an attention/orienting response, which is accompanied by a reduction in HR (Graham & Clifton, 1966; Lacey & Lacey, 1970). After this first phase, HR usually increases and might again decrease under habituation to the stimulus over time.

Cortisol is released in response to activation of HPA and can also be reliably measured by saliva samples (Kirschbaum & Hellhammer, 1989; Pollard & Ice, 2007). SAMS usually reacts rapidly to a variety of stressors and is similar to the concept of arousal. The activation of HPA takes longer and requires more serious stressors which are often experienced as more uncontrollable and social-evaluative (Dickerson & Kemeny, 2004).

Although there are previous studies that focus on media use and stress, a systematic and comprehensive comparison of different types of media and content, including disparate physiological indicators, is still lacking.

In regards to HR, the majority of studies confirm that both television and video games induce a significant increase (Anderson & Bushman, 2001; Myrtek, Scharff, Brügger, & Müller, 1996; Segal & Dietz, 1991; Wang & Perry, 2006). Fleming and Rickwood (2001) compared a violent and a nonviolent video game and found that the violent content induced a greater increase in HR. Corresponding to this, Myrtek et al. (1996) reported higher HR in children for action-oriented and violent television programs than for other program content. HRV was not, however, analyzed in any of the studies.

Regarding changes in the concentration of catecholamines (norepinephrine and epinephrine) and sAA, the results are more ambiguous. Certain studies (Goldstein,

Eisenhofer, Sax, Keiser, & Kopin, 1987; Trap-Jensen et al., 1982) found that nonviolent games increased norepinephrine but not epinephrine, whereas an alternative study reports a significant increase in epinephrine but not in norepinephrine (Eisenhofer, Lambie, & Johnson, 1985). A rise of participants' sAA levels was observed by Skosnik, Chatterton, Swisher, and Park (2000) for a violent video game. All cited studies include only adult subjects. It remains unclear whether similar reactions can be found in children and adolescents.

As already mentioned, increased secretion of cortisol can usually only be observed for more intensive and serious stressors. No rise in cortisol in children was found for nonviolent video games (Denot-Ledunois, Vardon, Perruchet, & Gallego, 1998). There was also no indication of a general increase in cortisol in participants using violent video games (Skosnik et al., 2000). However, one study found higher cortisol levels in subjects who played a violent game accompanied by rock or techno music compared to a version without music (Hébert, Béland, Dionne-Fournelle, Crête, & Lupien, 2005). When examining the effects of stressful films, Berger et al. (1987) found increased cortisol levels in young men. Given the limited numbers of studies on cortisol and media use, the rather ambiguous results and the few studies that include children and adolescents, further research is certainly needed.

Furthermore, there is a promising new approach to studying media effects, which uses brain imaging procedures (Anderson et al., 2006; Carnagey, Anderson, & Bartholow, 2007). Results of these studies show that violent contents activate brain regions implicated in arousal, attention, detection of threat, and episodic memory (Murray, 2001; Murray et al., 2006). These brain areas (parts of the amygdala, hippocampus, and posterior cingulate) are involved in memory storage of emotional events and indicate that violent video contents are processed similar to realistic stressful events.

Goals of the Present Study

Taken together, results of previous studies support the assumption that media use might lead to changes in physiological activation. Since the majority of studies were conducted with adults, it is unclear whether children and adolescents show similar reactions. The aim of this study is to systematically compare the effects of violent and nonviolent content in video games and television on adolescent boys. It is expected that, in keeping with previous findings, the effects of violent content and video games on participants should exceed those of nonviolent content and television. This study focuses on boys, as they are the gender group with the broadest media use, particularly with regard to video games and violent content (Cherney & London, 2006; Garitaonandia, Juaristi, & Oleaga, 2001). Moreover, there is also a methodological reason not to include girls: as natural levels of cortisol are not the same among pubertal boys and girls, it would be inappropriate to compare and combine both genders in one study (Netherton, Goodyer, Tamplin, & Herbert, 2004).

Also interesting for study is the individual's experience of stress during media use. Previous studies found no correlation between physiological measurements and subjective ratings (Hébert et al., 2005; Myrtek et al., 1996). It follows that physiological stress reactions do not automatically lead to a corresponding subjective sensation and vice versa. There are two dimensions that should be considered when analyzing subjective experiences of stress: *distress* and *eustress* (e.g. Nelson & Simmons, 2004; Selye, 1980). *Distress* describes a negative experience of stress, feelings of strain, tension, worry, and fear. In contrast, *eustress* describes a positive feeling that is almost congruent to the concept of *flow-experience*

described by Csikszentmihalyi (e.g. 2000). *Flow* is characterized by enjoyment, lack of boredom, an energized feeling, full involvement in the activity, and a balance between situational demands and individual abilities. Using Csikszentmihalyi's (1993) descriptions of flow-creating activities, video games are especially likely to create flow-experiences (also Sherry, 2004). The understanding of eustress in the present study is based on the flow-concept, but also includes more general indicators of enjoyment and positive feelings such as relaxation and good mood. Violent content is expected to lead to higher distress ratings because of its emotionally arousing and stress-inducing components. Since violent content is usually more attractive to boys in particular (Cherney & London, 2006; Garitaonandia et al., 2001) the reported eustress experience might also be higher for violent content. This study further explores the difference between television and video games regarding distress and eustress, the expectation being that video games should have a larger impact than television due to their more interactive and captivating character (Gentile & Anderson, 2003). Additionally, correlations between physiological measurements and subjective ratings of experience will be assessed. Further analysis will concentrate on whether ratings of distress or eustress serve as moderator variables between media use and physiological reactions. Thus, this study also examines the degree to which subjective experience affects the level of physiological stress reactions.

Method

Sample

Participants were 98 boys from different schools in the city of Bielefeld (Germany). Beforehand, conductance of the study was approved by the ethical committee of the German Psychological Association. Participation in the study was voluntary and informed consent was obtained from the parents of the participating boys in advance. The boys provided their assent to the study immediately before the beginning of the data collection. They ranged in age from 12 to 14 years ($M = 12.77$, $SD = 0.74$) in accordance with the age limit stated for the used games and films (with the exception of one 11-year-old boy whose parents explicitly gave their consent for his participation as he turned 12 within a few days after the data collection). Participants represented all academic levels, spoke German fluently, and had no comprehension problems. Most of the boys were native German speakers ($N = 82$, 83.7 per cent).

Materials and Measures

Television programs and video games. The included TV programs and video games were matched to ensure comparability. Video games that were based on television programs or films were chosen since they exhibit very similar storylines, similar features (such as main characters, atmosphere, etc.), and comparable levels of violence. Another criterion for the choice was the age limit: since the participating boys were underage, only games and films that were permitted for children aged 12 were considered. The entertainment show *Who Wants to Be a Millionaire?* was chosen as the nonviolent TV program. As an analogous video game, the *Junior-Edition* of a video game of the same title was chosen because of the more appropriate difficulty level of the questions. A section from the film *King Kong* (directed by Peter Jackson, 2005) and the corresponding video

game were used as violent video game and TV program. Both contain highly action-loaded and violent content, including many intensive fighting scenes and brutal assaults. The protagonists must defend and fight against fearsome creatures and mutated animals by means of physical violence and force of arms. Video games as well as TV programs were shown on laptop computers with headphones.

Heart rate (HR) and heart rate variability (HRV). Cardiovascular activity was measured by a Polar RS800 heart rate monitor. The monitor consists of a transmitting belt that is fastened around the chest and a wrist receiver. The unit of measurement for HR is beats per minute. Artifacts were controlled by the Polar software Pro Trainer 5. Since the heart rate monitor records every single R-R interval of heart beat, HRV can also be analyzed (see Task Force of Escardio and NASPE, 1996). The time-domain parameter SDNN (standard deviation of R-R intervals, measured in milliseconds) was chosen as a unit of measurement.

Cortisol and sAA. Saliva was collected using Salivette collection devices (Sarstedt, Nuembrecht, Germany). Free cortisol levels were measured using an immunoassay⁴ (IBL, Hamburg, Germany). Inter- and intraassay variations were below 15 per cent. For sAA a quantitative enzyme kinetic method was used as described elsewhere (van Stegeren et al., 2006). Level of cortisol was measured in nmol/l and concentration of sAA in U/ml.

Subjective experience. The subjective experience of media use was assessed by a questionnaire developed for this study. Some of the items were generated on the basis of the "Flow Short Questionnaire" by Rheinberg and Vollmeyer (2002) and the German Version of the "Positive and Negative Affect Schedule" (Krohne, Egloff, Kohlmann, & Tausch, 1996; Watson, Clark, & Tellegen, 1988). The questionnaire consists of two subscales: *distress* and *eustress*. The scale *distress* contains nine items with Cronbach's $\alpha = .74$. The *distress* items address negative feelings that indicate experience of stress, tension, and fear (e.g. "I felt strained," "I was scared"). Items concerning *eustress* contain enjoyment, positive feelings, and emotions (e.g. "I would like to keep on watching/playing," "I was in a good mood"). This scale contains 12 items with Cronbach's $\alpha = .91$. Participants were asked to answer on a four-point Likert scale including the stages (1) strongly disagree, (2) disagree, (3) agree, and (4) strongly agree.

Further, participants were asked to answer questions regarding their experiences with electronic entertainment media and their habits of media use.

Procedure

Data collection was conducted in the afternoon in rooms of the subjects' home institutions. This time of day was chosen, since cortisol underlies natural circadian variations. Cortisol levels are highest in the early morning hours and decrease during the day (Kiehl et al., 1995). The largest decrease can be observed from morning to midday, whereas the decline during afternoon hours is less pronounced. Participants were instructed not to eat or drink within 1 hour before the data collection and also not to perform any physical exercise, because otherwise levels of cortisol and sAA could be artificially increased at the beginning of the experiment (Pollard & Ice, 2007).

The boys were tested in small groups ranging from one to five children. Each group of participants was randomly assigned to the different experimental conditions (see Table 1).

TABLE 1

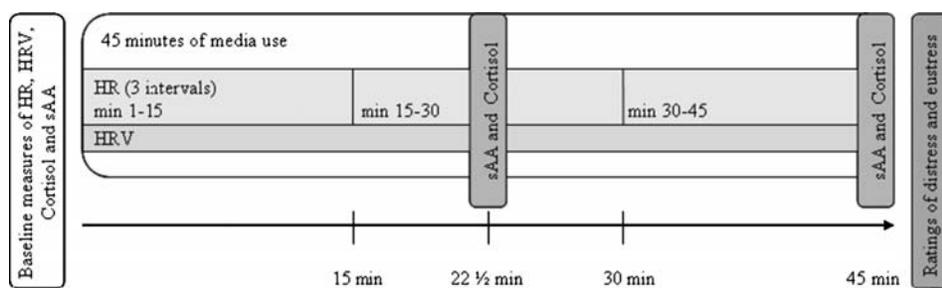
Assignment of participants to the different experimental groups

Content	Type of Media		
	Television Program	Video Game	Total
Violent	$n = 24$	$n = 25$	$N = 49$
Nonviolent	$n = 24$	$n = 25$	$N = 49$
	$n = 48$	$n = 50$	$N = 98$

During the experimental procedure the participants were placed in front of separate laptops and apart from each other to avoid distraction among them. After a short introduction, either one of the video games or films was presented for 45 minutes. During media use, HR and HRV were continuously measured. HR data was broken down to three periods of 15 minutes each. HRV was analyzed for the whole period of 45 minutes. Salivary samples were taken after 22½ minutes and at the end after 45 minutes. The participants were instructed to avoid movements with their extremities and not to speak while watching or playing. It was explained to them that physiological measurements could be affected by bodily movements. This instruction was given to ensure that participants only showed marginal negligible hand movements while controlling the game pad during playing. Baseline measures of cortisol and sAA were assessed prior to the period of media use. Further, baselines of HR and HRV were taken for 2 minutes. Immediately after watching a film or playing a game, participants were asked to rate their subjective experience of the media use (see Figure 1).

Statistical Analysis

For each physiological parameter, first changes in comparison to baseline were calculated either by *t*-test for dependent samples or by repeated measure ANOVAs including within-subject contrasts (Helmert procedure). Group comparisons were tested by univariate ANCOVAs, in parts with repeated measures, followed by post hoc multiple comparisons with adjustment of α (Bonferroni procedure). Baseline measures served as covariates, since equality regarding the different physiological baseline measures between

**FIGURE 1**

Sequence of the experimental procedure. HR = heart rate, HRV = heart rate variability, sAA = salivary alpha-amylase

the different groups was not always given. Cortisol, sAA, and HRV data were log-transformed to attain normal distribution.

Data of subjective experience were analyzed by nonparametric statistical procedures (Mann-Whitney U-Test, Kruskal-Wallis Test). In case of multiple group comparisons, again α was adjusted. Intercorrelations between ratings of subjective experience and physiological data were calculated by partial correlations, with baseline measures of the physiological data as control variables. Moderator analyses were calculated by means of stepwise hierarchical regression as described by Baron and Kenny (1986).

Univariate analyses were calculated for each variable, because either no significant intercorrelations were found between them or measures were derived from unequal lengths of time intervals and hence could not be joined together in one multivariate analysis. In case of directional hypotheses, one-tailed significance tests were calculated.

Results

Sample Characteristics Regarding Habitual Media Use

Participants reported that they watch TV for almost 2 hours on schooldays ($M = 1.72$, $SD = 0.92$) and for about 2.5 hours on weekend days and during holidays ($M = 2.55$, $SD = 0.98$). The reported durations for video game playing were equally high (schooldays: $M = 1.77$, $SD = 0.87$; weekends/holidays: $M = 2.43$, $SD = 1.02$). The boys were also asked to report their favorite genre of video games and television programs. Action games and movies (games: 43.9 per cent, $n = 43$; movies: 35.7 per cent, $n = 35$) as well as sports games and programs (games: 30.6 per cent, $n = 30$; programs: 16.3 per cent, $n = 16$) were among the most favored.

Hence, all participants were experienced users of electronic entertainment media as are most boys in this age group in Germany. The four experimental groups did not differ significantly regarding reported durations of habitual media use and preferred genres.

Heart Rate

Separate repeated measure ANOVAs including within-subject contrasts show that HR significantly increased in each experimental group from baseline to media use: nonviolent film: $F(1, 23) = 79.41$, $p < .01$, $Eta^2 = .775$; nonviolent video game: $F(1, 24) = 54.74$, $p < .01$, $Eta^2 = .695$; violent film: $F(1, 23) = 32.15$, $p < .01$, $Eta^2 = .583$; violent video game: $F(1, 24) = 56.79$, $p < .01$, $Eta^2 = .701$ (for means and standard deviations see Table 2).

As comparisons between different types of media and contents show, HR is higher for video game playing than for television watching, $F(1, 93) = 8.36$, $p < .01$, $Eta^2 = .082$, and, against the previous expectations, higher for nonviolent content than for violent, in general, $F(1, 93) = 7.07$, $p < .01$, $Eta^2 = .071$. An interaction effect was found for time and content, Wilks' Lambda, $F(2, 92) = 6.71$, $p < .01$, $Eta^2 = .127$ (see Figure 2), indicating that HR takes another course for violent contents than for nonviolent ones. For the middle time interval (minutes 15–30), no difference in level of HR was found for nonviolent and violent content, whereas HR is higher for nonviolent content during the first (minutes 1–15, $p < .01$) and the last (minutes 30–45, $p < .01$) period. Comparisons between the four experimental groups also show significant differences, $F(3, 93) = 5.53$, $p < .01$, $Eta^2 = .151$. As post hoc tests show, the course of HR declines over the three intervals for the nonviolent

TABLE 2
Means and standard deviations (in parentheses) of HR measures of baseline and three intervals during media use

	Type of Media						Content	
	Nonviolent Film	Nonviolent Video Game	Violent Film	Violent Video Game	Television	Video Game	Nonviolent	Violent
Baseline	78.71 (10.77)	79.52 (12.88)	77.79 (8.87)	85.04 (7.19)	78.25 (9.77)	82.28 (10.69)	79.12 (11.78)	81.49 (8.77)
Minutes 1–15	86.33 (11.55)	88.63 (11.90)	81.20 (10.63)	91.62 (8.37)	83.77 (11.28)	90.12 (10.30)	87.50 (11.67)	86.52 (10.81)
Minutes 15–30	85.62 (10.84)	88.24 (11.78)	82.70 (9.62)	92.22 (7.58)	84.16 (10.24)	90.23 (10.01)	86.96 (11.29)	87.56 (9.81)
Minutes 30–45	85.00 (10.14)	87.35 (11.37)	80.95 (9.30)	90.82 (7.61)	82.97 (9.84)	89.08 (9.73)	86.19 (10.74)	85.98 (9.76)

Note: N = 98.

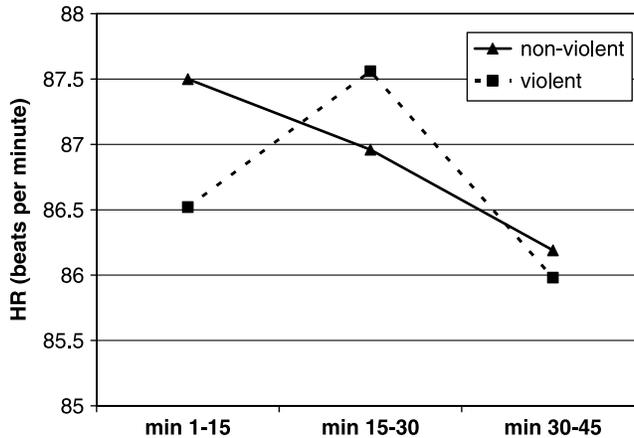


FIGURE 2

Means of HR (beats per minute) for three intervals during media use (minutes 1–15, minutes 15–30, minutes 30–45) for nonviolent and violent contents. Interaction effect time × content: $p < .01$, $Eta^2 = .127$

film and game, whereas for the violent contents an increase from first to second time interval and then a decrease from second to third interval was observed (for means and standard deviations see Table 2). These results conform to the effects regarding content and type of media in general mentioned above.

Heart Rate Variability

HRV decreases from baseline to media use in all groups: nonviolent film, $t(23) = 3.36$, $p < .01$; nonviolent video game, $t(24) = 1.75$, $p < .05$; violent film, $t(23) = 2.52$, $p < .05$; violent video game, $t(24) = 5.72$, $p < .01$ (for means and standard deviations see Table 3). Comparisons between the experimental groups show that they differ regarding HRV during media use, $F(3, 93) = 3.40$, $p < .05$, $Eta^2 = .099$. Multiple one-tailed comparisons yield the result that significant differences can be observed between the group that played the violent video game and each other group ($p < .05$ each; see Figure 3). Players of the violent game exhibit lower HRV than the other participants. This indicates that with regard to HRV, the violent game induces the highest level of stress.

Video games, in general, cause lower HRV than television, $F(1, 93) = 3.84$, $p < .05$, $Eta^2 = .039$, and violent content induces lower HRV than nonviolent content, $F(1, 93) = 3.80$, $p < .05$, $Eta^2 = .040$ (for means and standard deviations see Table 3).

Alpha-Amylase

For sAA, only 88 participants were included in the analysis because of insufficient amounts of saliva in the samples ($n = 6$) and elimination of outliers (extreme values in box plots, $n = 4$). SAA rose in three of the four experimental groups from baseline to media use: nonviolent film, $F(1, 19) = 5.04$, $p < .05$, $Eta^2 = .210$; violent film, $F(1, 22) = 18.18$, $p < .01$, $Eta^2 = .452$; and violent video game, $F(1, 21) = 14.14$, $p < .01$, $Eta^2 = .402$ (see Table 3).

TABLE 3
Means and standard deviations (in parentheses) of log-transformed HRV, cortisol, and sAA measures for baseline and period of media use

	Type of Media						Content	
	Nonviolent Film	Nonviolent Video Game	Violent Film	Violent Video Game	Television	Video Game	Nonviolent	Violent
HRV (N = 98)								
Baseline	4.25 (0.37)	4.19 (0.35)	4.21 (0.35)	4.10 (0.37)	4.23 (0.36)	4.15 (0.51)	4.22 (0.51)	4.16 (0.36)
Media use	4.13 (0.39)	4.07 (0.42)	4.08 (0.32)	3.84 (0.38)	4.10 (0.35)	3.96 (0.41)	4.10 (0.40)	3.96 (0.37)
sAA (N = 88)								
Baseline	3.37 (0.85)	3.58 (0.71)	3.41 (0.98)	3.52 (0.84)	3.39 (0.91)	3.55 (0.76)	3.48 (0.77)	3.47 (0.90)
After 22½ min	3.52 (0.72)	3.54 (0.68)	3.70 (0.80)	3.74 (0.84)	3.61 (0.76)	3.63 (0.76)	3.53 (0.69)	3.72 (0.81)
After 45 min	3.72 (0.66)	3.49 (0.77)	3.72 (0.88)	3.83 (0.84)	3.72 (0.77)	3.66 (0.81)	3.60 (0.72)	3.77 (0.85)
Cortisol (N = 96)								
Baseline	1.50 (0.61)	1.57 (0.69)	1.22 (0.71)	1.53 (0.62)	1.36 (0.67)	1.55 (0.65)	1.53 (0.65)	1.38 (0.68)
After 22½ min	1.18 (0.59)	1.09 (0.70)	1.12 (0.64)	1.20 (0.58)	1.15 (0.61)	1.15 (0.63)	1.13 (0.64)	1.16 (0.61)
After 45 min	0.97 (0.50)	0.82 (0.64)	0.96 (0.56)	0.96 (0.63)	0.96 (0.53)	0.89 (0.63)	0.89 (0.58)	0.96 (0.59)

Note: sAA and cortisol separated for measurement during—at 22½ minutes—and immediately after—at 45 minutes—media use.

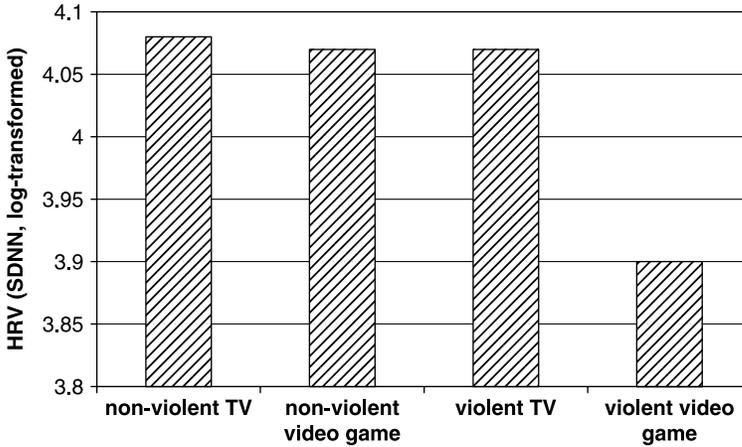


FIGURE 3

Estimated means (adjusted for baseline) of HRV. SDNN, log-transformed; group differences: $p < .05$, $Eta^2 = .099$; post hoc tests: violent video game is lower than all other groups: $p < .05$ each

Corresponding to this, groups differ in their levels of sAA during and immediately after media use, $F(3, 83) = 3.87$, $p < .05$, $Eta^2 = .123$, whereby the group playing the nonviolent game showed significant lower levels of sAA than the group watching the violent film ($p < .05$) and the group playing the violent game ($p < .05$; for means and standard deviations see Table 3).

Consequently, violent content, in general, causes higher levels of sAA (during and immediately after media use) than nonviolent contents, $F(1, 83) = 6.27$, $p < .01$, $Eta^2 = .070$, whereas no main effect of type of media was found, $F(1, 83) = 2.62$, *ns*.

Cortisol

A total of 96 participants were included in the analysis (two missing because of insufficient amounts of saliva). A significant decrease was found for three experimental groups between baseline and the two following measures during and after media use: nonviolent film, $F(1, 22) = 27.98$, $p < .01$, $Eta^2 = .560$; nonviolent video game, $F(1, 23) = 121.39$, $p < .01$, $Eta^2 = .841$; and violent video game, $F(1, 24) = 27.86$, $p < .01$, $Eta^2 = .537$ (for means and standard deviations see Table 3). Basically, for the violent film a decrease was also observed but did not reach significance, $F(1, 23) = 2.39$, *ns*. Regarding comparisons of the four experimental groups, a repeated measure ANCOVA shows that there are significant differences, $F(3, 91) = 2.81$, $p < .05$, $Eta^2 = .085$. Multiple post hoc tests come to the result that significant differences exist only between the violent film and the nonviolent video game ($p < .05$), the violent film being associated with higher levels of cortisol during media use. This result corresponds with the significant main effect of type of media, $F(1, 91) = 4.77$, $p < .05$, $Eta^2 = .050$, which shows a higher level of cortisol for television than for video games. A main effect of content was also found, $F(1, 91) = 3.80$, $p < .05$, $Eta^2 = .040$: violent content causes higher concentrations of cortisol than nonviolent content (see Table 3).

In addition, it should be mentioned that the general decline in concentrations of cortisol over time was not observed in all participants. Altogether there were 32 boys who showed an increase either from baseline to one of the measures during or after media use or from the measure during media use to the one afterwards. Most of these boys ($n = 13$) belonged to the group watching the violent film, nine watched the nonviolent film, and five boys each played a nonviolent or violent video game, $\chi^2 = 8.72, p < .05$.

Subjective Experience

Nonparametric analysis yields the information that ratings of eustress, $\chi^2 = 33.92, p < .01$, and distress, $\chi^2 = 18.75, p < .01$, differ between the four experimental groups (see Table 4). One-way comparisons show that for the violent video game and the violent film more eustress was reported than for either the nonviolent game or film: violent video game vs. nonviolent video game, $U = 117.00, p < .01$; violent video game vs. nonviolent film, $U = 102.50, p < .01$; violent film vs. nonviolent video game, $U = 90.00, p < .01$; violent film vs. nonviolent film, $U = 76.50, p < .01$. No differences regarding eustress were observed between nonviolent game and film, $U = 285.50, ns$, nor between violent game and film, $U = 275.00, ns$. Furthermore, no differences in distress ratings were found for nonviolent film and game, $U = 245.00, ns$, nor for violent film and game, $U = 224.50, ns$. Experienced distress was significantly higher for both playing the violent video game than for watching the nonviolent film, $U = 147.50, p < .01$, and for playing the nonviolent game, $U = 119.00, p < .01$. Watching the violent film also results in higher distress ratings than both playing the nonviolent video game, $U = 170.50, p < .01$, or watching the nonviolent film, $U = 201.00, p < .05$.

Corresponding to this, both distress and eustress ratings are higher for violent content than for nonviolent, in general: distress, $U = 638.00, p < .01$; eustress, $U = 386.00, p < .01$. Regarding comparison of types of media, no differences were found between television and video games for experienced distress: $U = 1156.50, ns$, and eustress, $U = 1177.00, ns$.

Subjective Experience and Physiological Data

Aside from one significant correlation, $r = .31, p < .01$, between level of sAA immediately after media use and experience of distress during media use, no significant correlations were found between subjective experience and physiological data. Further, ratings of distress and eustress are not significantly correlated, $r = .17, ns$.

Finally, it was analyzed if subjective ratings of distress or eustress serve as moderator variables and, therefore, affect the relation between media use and level of physiological stress reaction. Based on hierarchical regression (Baron & Kenny, 1986), neither subjective ratings of distress nor eustress could be identified as moderator variable between media use and any of the physiological outcome measures.

Discussion

Summary and Interpretation of the Results

The data show that media use in general causes physiological stress reactions, more precisely an activation of SAMS. Presumably, there was no strong activation of HPA because

TABLE 4
Means and standard deviations (in parentheses) regarding ratings of subjective experience of media use

	Type of Media								Content	
	Nonviolent Film	Nonviolent Video Game	Violent Film	Violent Video Game	Television	Video Game	Nonviolent	Violent		
Distress	1.58 (0.49)	1.45 (0.42)	1.77 (0.45)	1.97 (0.48)	1.68 (0.48)	1.71 (0.52)	1.51 (0.46)	1.88 (0.47)		
Eustress	2.53 (0.75)	2.57 (0.68)	3.48 (0.32)	3.38 (0.54)	3.00 (0.75)	2.98 (0.73)	2.55 (0.71)	3.42 (0.44)		

Note: N = 98.

cortisol follows the usual circadian pattern and decreases on average over time (Kiehl et al., 1995). Nevertheless, there was even an increase in cortisol observed for some of the participants, indicating interindividual differences regarding secretion of cortisol.

The assumption that type of content influences physiological and psychological media effects was supported by results regarding sAA, cortisol, and HRV: violent contents are associated with higher levels of stress. For HR, a contrary effect was observed: HR was higher for nonviolent content than for violent content. However, HR takes another course in the case of violent content: although HR decreases over time for nonviolent content, it first increases and later decreases for violent content. From this, it can be interpreted that in the case of violent content, an initial increase in attention and concentration (accompanied by lowered HR) can be observed (Graham & Clifton, 1966; Lacey & Lacey, 1970). Afterwards, HR rises and reaches an equally high level as that of nonviolent films and games. This increase is followed by a habituation during the last time interval, indicated by decline of HR. This habituation is observed for nonviolent content from the outset on. Therefore, although in total HR is overall lower for violent contents, different patterns of physiological HR reactions suggest that violent films and games have a more complex effect on cardiovascular reactions and might also be processed in a different way.

In addition, both subjective distress and eustress ratings were higher for violent content. This indicates that violent films and games lead to a higher stress response in general, accompanied with more negative, but also with more positive emotions.

Regarding effects of type of media, video games induce higher levels of HR and lower levels of HRV than television programs. Both findings indicate a stronger stress response to video games. Contrary to the assumptions, levels of cortisol are higher for participants watching television than those playing video games. This result is due in large part to the higher levels of cortisol for the violent film. Furthermore, type of media in general does not seem to influence subjective ratings of experienced distress and eustress. To draw a more tangible conclusion: although there is an effect caused by type of media, the content in general seems to be the more relevant factor in terms of physiological reactions and subjective experience.

Subjective experience of media use does not show strong correlations with physiological data and does also not serve as moderator variable. This result corresponds to findings by other research groups (e.g. Hébert et al., 2005; Myrtek et al., 1996) and indicates that physiological processes and subjective experiences deliver independent information.

Limitations

The presented video games and television programs represent only one specific choice of possible selections. Subsequent studies should include supplementary games and films to replicate the results. This also implies inclusion of different age groups and both genders to reach a broader generalization. Including a control group without media use would yield more detailed possibilities of comparison.

For ethical reasons, only games and films that are permitted for children aged 12 were included. This does not reflect the factual habits of media use reported by children and adolescents, considering that films and video games that are not permitted for underage children experience great popularity (Möble, Kleimann, & Rehbein, 2007). In this study, the majority of boys reported occasionally playing video games (69 per cent) or

watching films (70 per cent) that are not permitted for their age group. In these cases, even more intense effects regarding psychophysiological factors can be expected due to higher levels of violence (which is the basis for the media's age restrictions). Thus, the effects reported in this paper are probably underestimated.

Conclusion and Implications

The findings raise other questions regarding continuative impacts of media-induced stress reactions. It should be explored whether the detected effects of media use are strong enough to explain and codetermine further influences of media on adolescents' aggression, well-being, and academic performance.

In terms of aggression, the level of media-induced stress might moderate the impacts of violent content. Further research might include measurement of physiological parameters and the examination of interindividual differences regarding these outcome measures. This might yield more information on differential effects of violent contents on aggression and the underlying mechanisms.

In terms of well-being, further studies might concentrate on the relationship of physical and psychological health and habitual media use accompanied by bodily stress reactions. Excessive habitual exposure to certain types of media might increase the risk for health problems. There might be an effect determined by type of media and (especially) content, supposing violent content to have the most negative influences on well-being.

Last but not least, media-related stress reactions may impair cognitive processes and, therefore, have a negative impact on academic performance. First evidence for a direct association between excessive video game as well as TV exposure and memory performance comes from a study by Dworak, Schierl, Bruns, and Strüder (2007). They found playing an activating video game to be associated with a decline in verbal memory performance in children. Additionally, Bushman (1998) reported that the content of a TV program has an impact on memory for embedded commercials: participants who watched a violent film remembered fewer commercials than participants who watched a nonviolent film. Whether or not these effects were mediated by physiological stress reactions remains open. In this context, it also seems important to concentrate on interindividual differences, since SAM and HPA reactivity differ substantially between individuals. Further research studies should concentrate on these aspects to yield more comprehensive results regarding the effects of media use on children and adolescents.

NOTES

1. The SAMS is a major component of the biological stress system. Epinephrine and norepinephrine are released by the adrenal medulla under SAMS activation and cause a series of physiological changes (e.g. increased sweating, faster pulse, repression of digestion) that represent an adaption to environmental stressors and invoke the "fight or flight" response.
2. The HPA is the other major component of the biological stress system. It controls the secretion of cortisol (released by the adrenal cortex), which reins in the activities of other bodily systems and helps the body prepare for subsequent stressors.
3. Alpha-amylase is a protein component of human saliva. Sympathetic stimulation (activated by norepinephrine) leads to higher levels of protein concentrations in saliva.

The underlying processes responsible for stress-induced changes in alpha-amylase levels are not entirely clear yet.

4. An immunoassay is a biochemical test. It analyzes the concentration of a substance in bodily liquids (e.g. urine or serum) by utilizing the reaction of an antibody to its antigen.

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