MEDIA PSYCHOLOGY, 8, 323–341

Repeated Exposure to Video Game Play Results in Decreased Blood Pressure Responding

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Repeated exposure to violent media is related to negative outcomes, including aggression, hostility, and cognitive and social deficits. We examined if cardiovascular and emotional responding to video game play changed across 3 weekly sessions. Participants were 41 adolescents (*M* age = 14.8; male = 29; female = 12) from rural Appalachia. Participants attended 3 weekly sessions and played 1 of 3 video games (basketball, fighting, or horror) each time. Measures included heart rate (HR); systolic blood pressure (SBP); diastolic blood pressure (DBP); self-reported aggression, anger, and reactions to game play; and history of video game play. Resting and posttest cardiovascular measures did not differ from session to session. Adolescents displayed HR and SBP reactivity to game play within each session. They also demonstrated decreased SBP and DBP responding to video game play across the 3-week period, regardless of game content. Affective responses did not change significantly across the course of the experiment. Adolescents who played the violent games reported more frustration and arousal than those who played the sports game. The implications of these findings are discussed.

Violent media is a pervasive and disquieting presence in our society. Video games are a growing concern as they become more realistic, violent, and sexual in nature (Panee & Ballard, 2002). Violent video games often affect players in ways that increase the likelihood of aggression (e.g., increased arousal, negative affect, and aggressive cognitions; C. A. Anderson & Bushman, 2001; C. A. Anderson & Dill, 2000; Ballard & Lineberger, 1999; Ballard & Wiest, 1996; Panee & Ballard,

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2002). Among those who are at risk—due to dispositional or contextual factors—repeated exposure to violent media may increase tolerance of aggression or create a desire for more violent stimuli, as players become accustomed to acting out violence (C. A. Anderson & Dill, 2000; Grossman, 2000). Decreased physiological and affective responding to media stimuli may play a role in this process. This study examined if several dependent measures (i.e., heart rate, blood pressure, and affect) decreased in response to repeated video game play.

Video game aficionados report that game play is enjoyable, fosters positive moods, and, depending on the circumstances, engenders catharsis (e.g., Ballard & Hamby, 2003). However, several studies indicate that frequent video game play is correlated with negative social, cognitive, and behavioral sequela regardless of content. Repeated exposure to video games with *violent* content is correlated with more serious problems, including poor social and cognitive functioning and antisocial behaviors (C. A. Anderson & Bushman, 2001; C. A. Anderson & Dill, 2000; Funk, Buchman, Jenks, & Bechtoldt, 2003; van Schie & Wiegman, 1997). Aggressive and/or alienated youths are more likely to display a preference for violent video games (Slater, 2003). A time-lag study indicates that aggressive behavior and violent media use have bidirectional, reciprocal effects, with both increasing over time (Slater, 2003; Slater, Henry, Swaim, & Anderson, 2003).

There is experimental evidence that the intensity of violence within a video game also affects physiological and behavioral responses; greater game violence is related to higher hostility, heart rate, systolic blood pressure, and physical aggression and lower prosocial behavior (C. A. Anderson & Dill, 2000; Ballard & Lineberger, 1999; Ballard & Wiest, 1996; Panee & Ballard, 2002). This evidence is contradicted by studies that have not found a relation between game violence and aggression (e.g., Scott, 1995; Winkel, Novak, & Hopson, 1987). A recent study (Funk et al., 2003) that examined the impact of exposure to violent and nonviolent video game play on empathic responding to social vignettes found no impact of game genre on empathic responding. However, history of violent game play and initial empathy scores were related to empathic responding, indicating that individual differences moderate the effect of video game play.

Meta-analytic studies have not resolved this issue. An analysis of 32 published studies concluded that the link between violent video game play and aggression was less significant than the impact of television violence on aggression and that extended playing further reduced these effects (Sherry, 2001). Another meta-analysis, using 35 published studies, reported substantive cognitive and behavioral effects of violent video game play, including aggression (C. A. Anderson & Bushman, 2001). These findings suggest that there is no simple link between violent video game play and undesirable outcomes.

Given the complexity of factors involved, Anderson and colleagues (C. A. Anderson & Bushman, 2002; C. A. Anderson & Dill, 2000) proposed the General

Aggression Model to integrate the social–cognitive phenomenon related to responding to violent media. Anderson and Bushman view violent video games as negative stimuli and suggest that they impact behavior via the interaction of reinforcement, negative affect, arousal, cognitive priming, and desensitization. For example, there is modeling and reinforcement of violence (vis à vis Bandura, 1977) in video games. In laboratory settings video game play often elicits anger and hostility (Ballard & Lineberger, 1999; Ballard & Wiest, 1996; Calvert & Tan, 1994; Panee & Ballard, 2002) and primes aggressive cognitive scripts (C. A. Anderson, 1997; C. A. Anderson, Benjamin, & Bartholow, 1998; C. A. Anderson & Dill, 2000; Bushman, 1998; Panee & Ballard, 2002), which increase the likelihood of aggression (Berkowitz, 1998; Canary, Spitzberg, & Semic, 1998). However, stimulating media that is perceived as positively arousing by fans (e.g., violent games or heavy metal music) is often perceived as negatively arousing by others (Snider, Ballard, Curtin, & Zrull, 2004). In natural settings video game play may elicit negative or positive emotions and peer interactions, depending on performance, competition, and other contextual factors. Because physiological arousal holds no valence without cognitive mediation (e.g., Blascovich, 1990; Snider et al., 2004), the circumstances surrounding game play are necessary to predict if a cycle of negative affect and aggression, or a cycle of positive affect and affiliation, is likely to occur.

While the above issues (i.e., negative affect, arousal, cognitive priming) have been relatively well-researched, the phenomenon of desensitization, or becoming less responsive to violent media stimuli over time, has not been well-examined. There is little research on desensitization to environmental stimuli. Despite this, there has been an assumption that violent media has a desensitizing effect—that is, that repeated exposure to violent media reduces or eliminates the individual's physiological, cognitive, and emotional responses to violent stimuli (Rule & Ferguson, 1986). In particular, Anderson and Dill (2000) suggest that repeated exposure to violent games results in an increased tolerance for violence, decreased physiological arousal, and decreased affective responding. Such desensitization is conjectured to increase dispositional (e.g., trait) anger and hostility and, ultimately, to increase the likelihood of behavioral aggression. Grossman (2000) suggests that desensitization to game violence might induce players to perpetrate real-life violence to meet increased needs for aggression. However, others (D. R. Anderson, Huston, Schmitt, Linebarger, & Wright, 2001) argue that *any* stimulating media can result in increased arousal or aggression and that anxiety is a more likely outcome of exposure to violent media than desensitization (Potter & Smith, 2000).

Currently, all of the published studies examining desensitization in response to violent media used *filmed violence* as stimuli. This may not be a good comparison, as TV and film are less active mediums than video games. Linz, Donnerstein, and Adams (1989) reported affective and cardiovascular desensitization to films containing violence against women. Men who were exposed to films containing violence against women were later less emotionally and physiologically reactive to a similar clip than men who had been exposed to arousing, but not violent, films about sports and sex. Margaret Thomas and colleagues (Drabman & Thomas, 1974; Thomas, 1982; Thomas & Drabman, 1975; Thomas, Horton, Lippincott, & Drabman, 1977) examined desensitization to televised violence. They exposed children and college students to aggressive and nonaggressive film segments and observed their behavioral and physiological reactions to the stimulus, including their tolerance of a "real life" aggressive episode. In sum, this research indicates that even minimal (15-min) exposure to televised violence leads to (a) increased tolerance of aggression (Drabman & Thomas, 1974; Thomas & Drabman, 1975), (b) lowered physiological reactivity (Thomas, 1982; Thomas, Horton, Lippincott, & Drabman, 1977), and (c) increased behavioral aggression (Thomas, 1982). However, Molitor and Hirsch (1994) failed to find significant differences in toleration of aggression among children exposed to violent versus nonviolent TV. Several factors, such as cohort differences or differences in stimuli, could account for these inconsistencies.

STATEMENT OF PROBLEM AND HYPOTHESES

There is evidence that exposure to violent media is related to aggressive behavior and cognitions and negative emotion. Some suggest that desensitization to violent media increases the likelihood of aggression by increasing tolerance for aggression (C. A. Anderson & Dill, 2000), leading to an appetite for real life aggression (Grossman, 2000) or decreasing empathic responding (Funk et al., 2003). These claims are based on an assumption that, over time, exposure to violent games lessens physiological arousal and affective responding to violent stimuli, including one's own aggressive behavior. This desensitization, coupled with readily primed violent scripts, is thought to increase the likelihood of aggression among those who frequently play violent video games. However, the studies that lend support to this claim were based on TV violence, are dated, have not been replicated, and/or had methodological weaknesses.

Using an adolescent sample, we examined, across a 3-week period, if cardiovascular and affective desensitization resulted from repeated exposure to video game play and if this was mediated by game genre. (For the purposes of this study, desensitization was defined as decreased cardiovascular and affective responding across the course of the 3-week period. Habituation was defined as decreased cardiovascular responding during a single session.). We established three hypotheses based on the literature and associated theory: (a) that adolescents would display cardiovascular and affective desensitization in response to video game play across a 3-week period (Anderson & Dill, 2000; Thomas, 1982) and that this effect would be greater for violent games (Ballard & Weist, 1996; Panee & Ballard, 2002); (b) that adolescents would display increases in heart rate and diastolic blood pressure and decreases in systolic blood pressure *within each session* and that this effect would be greater for violent games (Ballard & Weist, 1996; Panee & Ballard, 2002); and (c) that adolescents who played the violent video games would display more state anger and greater cardiovascular reactivity (e.g., C. A. Anderson & Dill, 2000; Ballard & Wiest, 1996; Bushman, 1998; Panee & Ballard, 2002).

METHOD

Participants

Participants were 42 adolescent (male = 29; female = 13) volunteers from an mid-sized Appalachian town. A female participant withdrew from the study after Session 1 due to the violence of the game (RE); her data is not included in the analyses. The remainder of the participants ($N = 41$) completed three sessions. Participants ranged in age from 12 to 18 ($M = 14.8$). Socioeconomic status, based on parental occupation and education, was well distributed across class. Most ($N = 38$) participants were White, two were Black, and one was Hispanic American; this is representative of the area (U.S. Bureau of the Census, 2001). Participants were recruited through TV and newspaper public service ads and flyers posted around the community. The adolescents were paid $30.00 for participation. They had typical game experience, reporting a median of 10 hr/week of video game play. They usually played video games with a male friend (42%) or alone (32%), typically while at home (90%). Participants were counterbalanced, accounting for gender, into three game genre conditions. An equal number ($N = 4$) of girls played each stimulus game. Among boys, 10 played *NBA Live* (NBA), 10 played *Resident Evil Director's Cut* (RE), and 9 played *Mortal Kombat* (MK). Each child played the same game across all three sessions.

Apparatus

A Sony PlayStation and analogue controller was used to play the stimulus game. Three games were chosen by a focus group of video game players as representative of the most popular genres and as varying in pace and level of violence. MK is a violent, fast-paced martial arts fighting game produced by Midway. Those in the MK condition used Johnny Cage, a muscular white male, to fight various combatants. RE is variably-paced action/adventure game, with spurts of violent action. RE is produced by CapCom. Participants in the RE condition used Chris Redfield, a muscular white male, to fight zombies and other creatures. NBA is a nonviolent, fast-paced basketball game produced by Electronic Arts Sports. Participants played with the Utah Jazz against the Chicago Bulls. RE is a role-playing game with a story line, while MK and NBA are comprised of discrete matches.

An Omron Model HEM-707 Automatic Oscillometric Digital Blood Pressure and Pulse Rate Monitor with Fuzzy Logic was used to monitor heart rate and blood pressure before, during, and following game play. An adult or pediatric blood pressure cuff was attached to the participants' left arm, which was stabilized by the arm of the recliner during the procedure to control for movement artifact. The cuff is inflated automatically by an electric pump, which uses fuzzy logic to determine cuff inflation. Heart rate and blood pressure are detected by a semiconductor pressure sensor and the oscillometric method to is used to yield blood pressure measures. Heart rate and blood pressure measures were recorded onto a data sheet from the digital LCD display. The HEM-707 is easy to use and is reliable for blood pressure (+/– 3mmHg) and heart rate (+/– 4 bpm; Omron, n.d.). Laboratory measures of cardiovascular reactivity are significantly, positively related to cardiovascular reactivity in the field (Jain, Schmidt, Johnston, Brabant, & von zur Muehlen, 1999). In applied terms, heart rate deceleration generally occurs during relaxation, stimulation of the parasympathetic nervous system, and as an orienting response. Heart rate typically increases with stress, physical exertion, and/or stimulation of the sympathetic nervous system. Likewise, increases in blood pressure are related to stimulation of the sympathetic nervous system, anxiety, and physical activity (Andreassi, 1980; Nance & Hoy, 1996).

Measures

Participants completed three weekly experimental sessions. Game play history, cardiovascular responses to game play, and state anger following game play were assessed each week. Other measures of anger and aggression varied from session to session. Measures of cardiovascular reactivity and arousal, anger, and aggression were used due to the theoretical links between these variables, media exposure, and behavioral aggression (e.g., C. A. Anderson & Bushman, 2001) and to be consistent with other research in the area (e.g., Thomas, 1982; Thomas et al., 1977). Different measures were used across sessions to (a) increase compliance, (b) avoid participant boredom, (c) decrease the likelihood of demand characteristics, (d) reduce practice effects, and (e) decrease the likelihood of acclimation to the experimental session. Data that were collected during each session were used to examine both the effects of video game play on responding across sessions and the effect of game genre. Measures that were gathered only once were used to examine only the impact of genre.

A survey was administered at the beginning of each session to assess game play history (see C. A. Anderson & Dill, 2000). Participants estimated the amount of time they had spent playing action/adventure, fighting, role playing, sports, and strategy games during the previous week. For each genre, participants reported the following data on game play: (a) days per week, (b) hr per week, (c) context, and (d) alone or with a partner.

A five-item Game Experience Questionnaire was completed by the participants after game play. Questions were counterbalanced across participants and sessions to control for order effects. Four questions assessed emotional reactions to game play. Participants responded to the questions "How enjoyable (or relaxing, arousing, or frustrating) did you find playing the video game today?" and replied using a 5-point Likert-type scale, ranging from 1(*not at all enjoyable — relaxing, arousing, or frustrating*) to 5 (*extremely enjoyable — or relaxing, arousing, or frustrating*). The fifth question asked participants to rate "How well did you play in comparison to how well you wanted to play?" from 1(*not at all like I wanted to play*) to 5 (*just like I wanted to play*).

The State-Trait Anger Expression Inventory (STAXI; Spielberger, 1996) was used to measure participants' state and trait anger. The 10-item State Anger subscale—which measures current feelings of anger—was completed after game play during all three sessions to gage the impact of game genre and session on feelings of anger. The entire 44-item STAXI was completed during Session 2 to examine the impact of game genre on subscale scores. The STAXI subscales have excellent reliability (α's range from .74 to α = .84) and validity (Spielberger, 1996). The Trait Anger subscale measures participants' general experience of anger, frustration, and unfairness. The Anger-In subscale measures the tendency to inappropriately refrain from displaying anger. The Anger-Out scale measures the tendency toward explosive anger. The Anger Control and Anger Expression subscales examine appropriate control and expression of anger.

After game play during Session 1, participants completed the 38-item Interpersonal Behavior Survey-Short Form (IBS; Mauger & Adkinson, 1993), a self-report inventory that measures Assertiveness ("I say what I want to say in most situations"), Aggressiveness (aggressive feelings and behavior, e.g., "Some people think I have a violent temper"), and Denial (reluctance to admit socially undesirable behavior, e.g., "I never make fun of people who do things I feel are stupid"). The IBS has excellent test–retest (r = .90) and internal reliability (Mauger & Adkinson, 1993). The IBS Aggression subscale was analyzed to examine if game genre affected self-report of aggressive tendencies during Session 1.

The Adjective Checklist (ACL), is a 200-item measure. Three ACL subscales, dominance (feelings of confidence, competence, independence, reliability, and self-efficacy), aggression (feelings of irritability, hostility, and anger), and affiliation (used as filler), totaling 144 adjectives, were used in this experiment. Participants completed the ACL after game play during Session 3. They were instructed to mark the 10 adjectives that best described their current mood. The

ACL is a reliable measure of feelings of dominance and aggression (r's range from .65 to .76; Fekken, 1984). It was used to examine the effects of game genre on self-reported feelings of aggression and dominance.

Game success scores were coded for each participant from summary statistics displayed on the screen during game play. For those in the NBA condition, shot percentage was used as the success score. For those in the MK and RE conditions, the number of opponents defeated, divided by the number of opponents encountered, was used as the success score.

Procedure

Each participant was called the night before each session to remind them of their appointment and to remind them not to exercise, or ingest caffeine, nicotine, or alcohol for 3 hr before the session. Due to the labor intensive nature of the procedure, two research assistants (one male and one female) were present to run each session.

During Session 1, parental consent and participant assent was obtained. The adolescent's parent completed a demographic form. The parent was allowed to inspect the lab but was not allowed to stay in the lab during the procedure. The lab was a large room furnished with a desk, desk chairs, bookshelf, small writing table, equipment table, recliner, a TV on a stand, and a Sony PlayStation. Each participant sat at the writing table to complete the video game play survey. After completing the survey, participants moved to the recliner and the appropriate-sized blood pressure cuff was attached to their left arm. The participant was asked to sit back, breath deeply, and relax. After the participant had relaxed for 5 min, two resting heart rate and blood pressure measures were taken, 5 min apart and recorded onto a data sheet.

Participants were familiarized with the assigned video game; game and controller commands were explained carefully. Participants were given 5 min to practice using the controller. After familiarization, the participant played the assigned game for 15 min, a common amount of exposure in research on TV and video games. Heart rate and blood pressure measures were taken at 3, 8, and 13 min after game play began. (To avoid movement or isometric confounds, game play was paused and the participant sat quietly while the blood pressure monitor was engaged. The game was restarted when the measure was complete.) After cessation of game play, participants were instructed to sit quietly and relax for post-game heart rate and blood pressure measures. Heart rate and blood pressure measures were gathered at 2 and 7 min after cessation of game play.

After the last cardiovascular measures were taken, the participant moved to the writing table to complete the Game Experience Questionnaire (GEQ), the IBS, and the STAXI State Anger subscale. Participants were informed that they would complete the IBS only during the first session but that they would complete the GEQ and State Anger Subscale during each session. The GEQ was completed first; the IBS and State Anger Subscale were counterbalanced. Participants were informed that they had completed the first session and were reminded of their appointment time for the next week.

Session 2 was similar to Session 1, except that the IBS was not administered after game play. Following game play the participants completed the GEQ and the entire STAXI at the writing table. The participants was told that they had completed Session 2 and reminded of their next appointment. Session 3 resembled Session 2, except that participants completed the ACL and State Anger Subscale at the end of the session. Finally, participants were paid, debriefed, allowed to ask questions, and thanked for their participation in the study.

RESULTS

Preliminary Analyses

Initial resting heart rate, systolic and diastolic blood pressure for each session; ACL, STAXI, and IBS subscale scores; and game success scores were analyzed for sex differences using t tests. Although the likelihood of family-wise error increases with numerous t tests, these analyses had little power, so alpha was set at $p < .05$. There was only one significant sex difference, males ($M = 125.41$, $SD = 10.20$) had higher initial resting systolic blood pressure during Session 1 (but not Sessions 2 or 3) than females ($M = 117.50$, $SD = 9.54$). As there were no other significant sex differences (p's range from .07 to .9), the data were collapsed across sex for the remaining analyses.

We used several repeated-measures analysis of variance (ANOVA)s to ascertain that participants did not display cardiovascular desensitization to the situation per se (rather than to video game play). We ran three repeated-measures ANOVAs (one for each cardiovascular measure) comparing the initial resting cardiovascular measures across the 3-week period with session as the repeated measure and the second resting measure as the dependent variable. The results were not significant, resting heart rate and blood pressure did not vary across session. We also examined postgame cardiovascular responses across the 3-week period using three repeated-measures ANOVAs (one for each measure) with session as the repeated-measure and the second postgame measure as the dependent variable. The results were not significant, postgame heart rate and blood pressure did not vary across session. That is, participants did not display cardiovascular acclimation to the situation across the 3-week period.

We examined game play history in relation to the anger and aggression scale scores, game experience variables, and resting cardiovascular arousal. Correlations were performed for total game experience and by genre (i.e., action-adventure [non-first-person-shooter], action-adventure [first-person-shooter], fighting, role play, sports, strategy, and total game experience). Only 3 of these 100 correlations (less than expected due to family-wise error) were significant, indicating that game play history was not related to the other variables. Thus, game history was not considered in the analyses.

Game success was examined using a 3 (weekly session) × 3 (game genre) mixed-design ANOVA. Success did not vary significantly across session, but did vary dependent on game genre, $F(2, 38) = 15.46$, $p < .001$, $\eta^2 = .45$. Pairwise comparisons indicate that participants performed better when playing NBA ($M = .62$; $SE = .04$; $p < .01$) and RE ($M = .72$; se = .04; $p < .001$) than MK ($M = .44$; $SE = .04$).

Cardiovascular Responses

Three separate 7 (measures within session) × 3 (weekly sessions) × 3 (game genre) mixed-design multivariate analysis of variance (MANOVAs) were used to examine three dependent variables—heart rate, systolic BP, and diastolic BP. The seven cardiovascular measures (two resting, three during play, and two following play) taken during each of the three sessions and the three weekly sessions served as the within-subjects factors. Game genre (MK, RE, or NBA) served as the between-subject factor.

With regard to heart rate, the MANOVA was significant for the main effect of measure within session, Hotelling's Trace $F(6, 33) = 2.57$, $p < .05$, $\eta^2 = .32$. There were no main effects for weekly session or game genre and no interactions. Pairwise comparisons indicate that, across the experimental session, heart rate decreased significantly immediately following the beginning of game play and then increased significantly, returning to baseline, as game play progressed. See Table 1 for means and standard error for measure within session, collapsed across weekly session, for all cardiovascular measures. Table 1 also contains p values for the paired comparison follow-up tests for the measure within session main effects for heart rate and systolic BP.

In terms of systolic BP, the MANOVA indicated significant main effects of both measure within session, Hotelling's Trace $F(6, 33) = 4.41$, $p < .01$, $\eta^2 = .45$ and across weekly session, Hotelling's Trace $F(2, 37) = 6.68$, $p < .01$, $\eta^2 = .27$. There was not a significant main effect of game genre and no significant interactions. Pairwise comparisons used to follow-up the main effect of *measure within session* indicate that systolic BP decreased significantly prior to game play, increased significantly following cessation of game play, and decreased significantly on the second postgame measure (see Table 1). Pairwise comparisons used to follow-up the main effect of *weekly session* show that systolic BP decreased significantly across the course of 3 weeks. Systolic BP was significantly lower during Session 3 than during Session 1 ($p < .001$; see Table 2 for means and standard error for weekly session for each cardiovascular measure).

TABLE 1
Changes in HR, SBP, and DBP During Game Play
(Collapsed Across Weekly Session)

	1 *Resting 1*	*2* *Resting 2*	*3* *Play 1*	*4* *Play 2*	*5* *Play 3*	*6* *Post 1*	*7* *Post 2*
HR	77.10	77.58	75.84	76.08	77.59	77.40	78.12
	(1.63)	(1.69)	(1.64)	(1.55)	(1.73)	(1.56)	(1.57)
SBP	119.48	115.41	115.98	114.63	115.05	121.16	113.75
	(1.69)	(1.48)	(1.44)	(1.74)	(1.78)	(7.41)	(1.46)
DBP	69.28	68.36	67.18	67.31	67.63	67.69	67.06[a]
	(1.24)	(1.16)	(1.16)	(.96)	(1.10)	(1.09)	(1.18)
1	—	$p < .001$	$p < .001$	$p < .01$	$p < .01$	n.s.	$p < .001$
2	n.s.	—	n.s.	n.s.	n.s.	n.s.	$p < .05$
3	n.s.	$p < .01$	—	n.s.	n.s.	n.s.	$p < .01$
4	n.s.	$p < .05$	n.s.	—	n.s.	n.s.	n.s.
5	n.s.	n.s.	$p < .01$	$p < .05$	—	n.s.	n.s.
6	n.s.	n.s.	$p < .05$	$p < .05$	n.s.	—	n.s.
7	n.s.	n.s.	$p < .01$	$p < .01$	n.s.	n.s.	—

Note. HR = Heart rate; SBP = systolic blood pressure; DBP = diastolic blood pressure; n.s. = not significant. Standard error is in parentheses; *p* values for SBP are above and HR are below the centerline. DBP means are presented for informational purposes.

[a] n.s.

The third MANOVA showed that diastolic BP decreased significantly across the three weekly sessions, Hotelling's Trace $F(2, 37) = 6.68$, $p < .01$, $\eta^2 = .27$. Diastolic BP was significantly higher during Session 1 than during Session 2 ($p < .01$) or Session 3 ($p < .01$). See Table 2 for means and standard error. There were no main effects for measure within session or game genre. There were no significant interactions.

To specifically examine desensitization to *active game play*, three repeated-measures ANOVAs (one for each cardiovascular measure) were performed using data points from mid-game play. The third cardiovascular measure taken during game play, across each session, served as the repeated-measure. See Table 2 for means and standard error. The results replicated those above. Heart rate did not vary during game play across weekly session. There were main effects of weekly session for both systolic BP, $F(2, 39) = 4.14$, $p < .05$, $\eta^2 = .18$, and diastolic BP, $F(2, 39) = 9.22$, $p < .001$, $\eta^2 = .32$. Pairwise comparisons indicate that systolic BP during game play was significantly higher during Session 1 than during Session 2 ($p < .05$) or Session 3 ($p < .05$) but did not differ from Session 2 to Session 3. Pairwise comparisons show that diastolic BP during game play was significantly higher during Session 1 than during Session 2 ($p < .001$) or Session

TABLE 2
SBP, DBP, and HR by Weekly Session
(Collapsed across Session and Active Game Play)

	Session 1	*Session 2*	*Session 3*
SBP (collapsed)	117.89 (1.54)	118.11 (3.27)	113.49 (1.63)
DBP (collapsed)	69.38 (1.12)	66.93 (1.19)	67.06 (0.99)
HR (collapsed)	77.75 (1.82)	77.05 (1.93)	76.50 (1.70)[a]
Game Play SBP	118.26 (1.72)	115.15 (1.83)	111.71 (2.80)
Game Play DBP	70.22 (1.38)	65.17 (1.23)	67.49 (1.06)
Game Play HR	78.66 (1.92)	76.71 (2.12)	77.56 (1.89)

Note. Standard error; except for HR all p's < .05. SBP = Systolic blood pressure; DBP = Diastolic blood pressure; HR = Heart Rate.

[a] not significant.

3 ($p < .05$). Further, diastolic BP was significantly higher during game play during Session 2 than Session 3 ($p < .05$).

Self-Reported Emotional Responses

A mixed-design, repeated-measures ANOVA, with weekly session as the repeated-measure and game genre as the between-subjects factor, was used to examine STAXI State Anger subscale scores. The results indicated that state anger did not vary across sessions. The main effect of game genre was not significant (See Table 3).

A MANCOVA, with game genre as the between-subjects variable, was used to examine subscores on ACL Aggression, Affiliation and Dominance; IBS Aggression; and STAXI Anger-Out, Anger-In, Anger Control, Anger Expression, and Trait Anger (See Table 3). This MANCOVA was not significant.

TABLE 3
State Anger, Aggression, and Trait Anger by Game Genre

	Total	*NBA*	*RE*	*MK*
State Anger (Session 1)	48.7 (4.1)	47.1 (2.2)	49.3 (3.7)	49.9 (5.6)
State Anger (Session 2)	48.0 (3.6)	46.6 (1.7)	49.1 (4.7)	48.1 (3.4)
State Anger (Session 3)	48.4 (4.7)	47.1 (2.7)	48.4 (3.1)	49.9 (7.1)
IBS Aggression (Session 1)	52.3 (9.3)	53.7 (12.8)	52.3 (7.5)	50.8 (6.7)
STAXI Anger Out (Session 2)	50.3 (9.7)	52.7 (9.3)	49.6 (8.9)	48.5 (11.2)
STAXI Anger In (Session 2)	44.9 (8.3)	44.3 (10.1)	45.4 (7.6)	44.9 (7.4)
ACL Aggression (Session 3)	−2.0 (3.9)	−1.9 (4.1)	−2.3 (2.9)	−1.6 (4.9)

Note. NBA = *NBA Live*; RE = *Resident Evil Director' Cut*; MK = *Mortal Kombat*; IBS = Interpersonal Behavior Survey-Short form; STAXI = State-Trait Expression Inventory; ACL = Adjective Checklist. Standard deviations are in parentheses. Negative numbers indicate lower aggression.

TABLE 4
Effects of Game Genre on Reported, Frustration, Arousal, and Perception of Game Play

	Mortal Kombat	*Resident Evil*	*NBA Live*
Frustration	2.41 (0.17)	2.14 (0.16)	1.52 (0.16)
Arousal	1.85 (0.18)	2.57 (0.18)	1.79 (0.18)
Played Well	2.69 (0.27)	2.81 (0.26)	3.69 (0.26)

Note. Standard error are in parenthese.

Game Experience Questionnaire

The GEQ assessed emotional reactions to game play (i.e., "How enjoyable [or relaxing, arousing, or frustrating] did you find playing the video game today?" and "How well did you play in comparison to how well you wanted to play?"). Responses to each GEQ question were analyzed using 3 (weekly session) × 3 (game condition) mixed-design ANOVAs. There were no significant main effects (game genre or session) or interactions for how relaxing or enjoyable participants found game play. For the other variables (arousal, frustration, and perception of game play), there were significant main effects of game genre but no main effects of weekly session and no interactions. See Table 4 for means and standard error for the effects of game genre on arousal, frustration, and perception of game play. Tukey HSD tests were used for post hoc analysis. In terms of frustration, $F(2, 38) = 7.58$, $p < .01$, post hoc tests indicate that the participants who played NBA experienced less frustration than those who played RE ($p < .05$) or MK ($p < .01$). Those who played NBA Live also felt that they had played better, $F(2, 38) = 4.44$, $p < .01$, those who played RE ($p = .05$) or MK ($p < .05$). RE elicited greater feelings of arousal, $F(2, 38) = 5.99$, $p < .01$, than MK ($p < .01$) or NBA ($p < .05$).

DISCUSSION

We examined if adolescents displayed decreased cardiovascular and affective responses to video game play across the 3-week period. Our hypotheses were that adolescents would display: (a) cardiovascular and affective desensitization in response to video game play across a 3-week period and that this effect would be greater for violent games; (b) increases in heart rate and diastolic blood pressure and decreases in systolic blood pressure *within each session* and that this effect would be greater for violent games; and (c) more state anger and greater cardiovascular reactivity after playing a violent game than after playing a sports game. The first two hypotheses were partially supported, but game genre did not significantly affect cardiovascular reactivity, desensitization, or anger responses to game play.

Specifically, in terms of desensitization, participants displayed decreased systolic and diastolic blood pressure reactivity to arousing video game play across the 3-week period. Participants displayed heart rate and systolic blood pressure reactivity, but not habituation, during each session of video game play. There were no differences in pregame resting or postgame recovery cardiovascular measures across sessions, which indicates that participants did not experience cardiovascular acclimation to the situation per se, but expressly to video game play. These findings are consistent with earlier findings on the desensitizing effects of film and TV (C. A. Anderson et al., 2001; Linz et al., 1989; Thomas, 1982; Thomas et al., 1977). Among our sample, declines in blood pressure across sessions occurred to active, arousing game play regardless of content. These findings suggest that—even with day-to-day exposure to a variety of violent and/or arousing media—repeated exposure to video game play results in cardiovascular desensitization.

In addition to decreased blood pressure across sessions, there were also significant variations in cardiovascular reactions to game play *during* each session. Heart rate decreased significantly immediately after game play began, which was likely an orienting response (e.g., Andreassi, 1980; Nance & Hoy, 1996). As game play continued, heart rate returned to baseline and increased after the cessation of game play. Likewise, Systolic BP decreased significantly in anticipation of game play, remained low during game play, and increased significantly only after the cessation of game play, similar to Panee and Ballard (2002). Together, these cardiovascular responses indicate parasympathetic nervous system activity during game play and suggest that participants relaxed while playing the game, regardless of content. Increases in heart rate and blood pressure immediately following game play indicate increased sympathetic nervous system activity, perhaps due to frustration related to having to stop in the midst of enjoyable game play (Kukleta, 2000; Nance & Hoy, 1996; Palomba, Sarlo, Angrilli, Mini, & Stegagno, 2000).

Though cardiovascular responses changed across the course of the experiment, self-reported feelings of anger and aggression did not vary by genre or across session. The participants had low mean anger and aggression scores and little variance in these variables, suggesting that our sample had low levels of dispositional anger and aggression, leaving little room for decreases in anger across time. Because dispositional anger and aggression moderates responding to violent video games (e.g., C. A. Anderson & Bushman, 2001; C. A. Anderson & Dill, 1999), greater effects of game genre or violent content might be found among adolescents with higher levels of dispositional anger or aggression. Replication of the experiment with a clinical sample would be beneficial in answering this question.

Though game genre had little impact on most of the variables examined (i.e., cardiovascular responses, anger, or aggression), the violent games (fighting and horror) elicited more frustration than the basketball game. Participants who played the basketball game also had better performance scores and reported being more satisfied with their game play than those who played the fighting or horror game. This suggests that the violent games were more difficult to play and, subsequently, more likely to elicit negative emotion. Finally, the horror game elicited more self-reported arousal than either the fighting or basketball game. RE might be perceived as more arousing because it has a story line, whereas the other games do not. That is, players may "get into" RE more than games that are comprised of discrete contests. Also, more sudden, frightening events occur during RE—for example, zombies that appear dead reach up and grab the protagonist's foot and rabid dogs abruptly jump through windows to attack the protagonist. These events might be perceived as more arousing than the more predictable events in the fighting or basketball game. So, even though the participants did not show differing cardiovascular responses to the different game genres, their perceptions indicate that the violent games made them feel more frustrated and aroused. Some studies have indicated that game genre or level of violence affect players' mood and behavior (e.g., Ballard & Lineberger, 1999; Ballard & Weist, 1996; Panee & Ballard, 2002), while other studies (e.g., Funk et al., 2003; Scott, 1995; Winkel et al., 1987) have not found that game genre affects behavioral responding. These inconsistencies could be due to a variety of factors, including differences in game stimuli, participant population, procedures and/or measures.

A few potential weaknesses in this study should be addressed. First, the sample was relatively small and, while representative of the area, homogenous. However, given difficulty of recruiting adolescents from this rural Appalachian community, we were pleased with the success of our recruitment and retention efforts. Second, the sample was not balanced for gender, we had the unusual circumstance of having a preponderance of male volunteers. As this gender disparity reflects a "real world" difference in the proportion of male and female adolescents who are gamers (Funk, 1993; Kubey & Larson, 1990), this is likely to increase external validity.

Several strengths of this study also warrant discussion. First, this study is one of few to employ a brief longitudinal design to examine the effects of video game play. Thus, the results yield important information about the extended effects of game play that cannot be examined in a single session. Second, it is improbable that boredom with the games or acclimation to the situation, rather than desensitization to game content per se, was related to cardiovascular and behavioral desensitization, as: (a) resting cardiovascular measures did not decrease from session to session, (b) responses to the GEQ indicate equivalent enjoyment of the game across sessions, (c) it is unlikely that players would become bored with a game after 45 min of game play, and (d) the procedure differed slightly from session to session to prevent boredom. Third, we had excellent retention across the course of the study. Fourth, we employed multiple measures, across multiple domains, to assess cardiovascular and emotional responding to game play. Finally, we examined a population—those in middle adolescence—for whom there has been concern regarding the impact of video game play.

Future research should focus on both the immediate and long-term physiological and behavioral responses to video games and other media (i.e., music, TV; McNamara & Ballard, 1999). In terms of physiological factors, additional cardiovascular measures, such as vagal tone and heart rate variability (e.g., Beauchaine, Gartner, & Hagen, 2000; Donzella, Gunnar, Krueger, & Alwin, 2000) should be used in future studies. Such measures will aid in teasing apart the impact of sympathetic and parasympathetic nervous system influences on reactivity and desensitization. In addition, hormonal indicators of physiological reactivity and arousal, such as cortisol (Donzella et al., 2000) or testosterone levels (Sanchez-Martin et al., 2000) should be incorporated into future studies. Furthermore, because individual difference factors appear to moderate responses to violent video games (Funk et al., 2003; Slater, 2003), responses to game play should be examined in relation to trait levels of anger, aggression, and empathy among participants (al'Absi, Bongard, & Lovallo, 2000; Anderson & Dill, 2000; Donzella et al., 2000). In addition, affective and behavioral responding should be examined more thoroughly across various game genres, taking violence, action, character gender, and other salient variables into account.

In summary, our results suggest that adolescents display cardiovascular desensitization to exciting video game play over time, regardless of game genre. As the desensitizing effect of game play is likely to have both cognitive and behavioral effects, our results have a variety of practical implications for educators and parents. At the least, we would expect desensitization to game play to be related to a desire to play new and/or increasingly arousing and aggressive games. Our results suggest that participants become desensitized to the level of activity in video games, which may lead them to want more active and perhaps, more realistic or more violent, games or other activities. Thus, these participants are likely to be less reactive to the action, gore, or violence in other games and in other contexts, such as TV shows. Our results also indicate that video game play per se might be relaxing for adolescents but that *cessation* of game play increases arousal. If so, increased arousal and negative affect after game play—rather than during game play—may be related to increased interpersonal aggression after game play (C. A. Anderson & Dill, 2000; Panee & Ballard, 2002).

ACKNOWLEDGMENTS

This project was supported by a grant from the Cratis D. Williams Graduate School at Appalachian State University.

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