Comfortably Numb? Violent Video Games and Their Effects on Aggression, Mood, and Pain-Related Responses

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Abstract. In contrast to findings that violent video game (VVG) exposure has a desensitizing effect on empathy and physiological reactivity to scenes of violence [1], no desensitization was found for player responses to pain stimuli in three lab experiments. Compared to a non-violent game, VVG exposure neither affected physiological responses, nor participants' self-reports of perceived pain caused by thermal stress. In addition, the level of game immersion did not affect pain perception, pain tolerance, or aggressive behavior (study 3). In contrast, violent game preference was associated with lower reports of perceived proximal pain, distal pain, and greater antisocial behavior. However, all studies confirmed the detrimental effect of VVG on emotion: participants reported lower positive and greater negative affect after playing the violent compared to the nonviolent game. In sum, the present findings speak against a generalized desensitization effect of VVG on the player. Rather, our findings further support the notion of pain and pain-related responses as complex and multidimensional, modulated by individual, physiological, and contextual factors [2].

Keywords: Violent video games · Desensitization · Pain · Pain perception · Mood

1 Introduction

The impressive economic and social success of video games as well as their potential effects has put the medium under extensive scientific scrutiny. In fact, whether violent video games (VVG) cause negative effects on player emotion, cognition and behavior has led to fierce debates among scholars [3–8]. In the light of the popularity and availability of video games (VG), the great interest of parents, stakeholders, and the general public about their potential effects, but also regarding current discussions about stable and consistent findings in psychology, replications, and meaningful advancements of existing approaches are inevitable to overcome simplifications and over-generalization of results on the effects of VVG.

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1.1 Violent Video Games and Aggression Desensitization

According to the General Aggression Model (GAM; [9]), VVG exposure can have short-term and long-term effects on aggression. Short-term exposure to VVG can influence a person's affect, arousal, or cognition, increasing the likelihood that the person will behave aggressively [9, 10]. In contrast, long-term exposure to VVG may in turn influence individual factors, leading to a desensitization effect, increased trait aggression or the reinforcement of attitudes and beliefs towards aggression [10].

The present study addresses findings of a desensitizing effect of VVG exposure. Desensitization is characterized as a decrease in the psychological and physiological response to a stimulus after continuous exposure [11]. Compared to non-violent games, playing VVG has been reported to reduce physiological and/or neurological arousal as well as emotional responding [11–13]. However, desensitization caused by VVG is believed to affect internal processes as well as social interactions. Violence in video games has been reported to increase aggressive behavior, reduce feelings of empathy in the players, and increase aggressive affect [1, 10]. Regarding the latter, feelings like hostility, anger, and a sense for vengeance are increased after VVG exposure [10] which also negatively impacts mood, increasing negative affect and decreasing positive affect [14–16]. Regarding feelings of empathy, participants that were exposed to VG violence showed reduced automatic emotional reactions to harm befalling someone else [17, 18]. For children and adolescents, VVG exposure is assumed to increase the risk of desensitization, possibly affecting aggression levels and decreasing prosocial behavior [19].

1.2 Violent Video Games and Pain Desensitization

Another likely candidate for the desensitizing effects of violence in VG is pain. Pain denotes a complex concept that is modulated by individual, physiological, and contextual factors [2]. Moreover, pain has individual as well as social aspects. Based on the assumptions in the GAM, the potentially numbing and the emotion desensitizing effect of playing VVG should result in stimuli perceived as less painful, both for pain directed to the self (i.e., proximal pain) and above all pain observed in others (i.e., distal pain). The latter is also affected by reduced empathic responses after VVG exposure [1]. For example, studies have shown that exposure to VVG leads to increased desensitization, reducing physiological and emotional reactions to stimuli [10, 11]. The present study therefore tested whether playing VVG has a desensitizing effect on participants' pain responses.

Regarding the role of VG in improving health-related outcomes, a meta-analysis confirmed the pain distracting effect of playing VG [20]. To date, however, only few studies have tested the effects of playing VG on pain perceptions directly. In one study, the so-called cold-pressor test was conducted, in which participants hold their hand in ice-cold water for as long as possible while taking out paper clips [21]. The experience of immersion during gameplay was crucial for pain sensitivity (Study 2): Compared to solving a non-immersive puzzle game, having played a first-person 3-D game led to greater pain tolerance (as indicated by the greater number of paperclips retrieved from ice-cold water), as well as greater indifference towards people depicted as experiencing displeasure. The authors attributed their findings to the desensitizing effect to pain in oneself and in others [21]. Stephens and Allsop [22] found that playing a VVG not only increased aggressive feelings and arousal (as indicated by heart rate), but also pain tolerance. Compared to a golf video game (i.e., the non-violent game), participants that had played a first-person shooter game found ice-cold water less painful (i.e., increased pain tolerance), as indicated by the longer time they held their hand in ice-cold water. The authors attribute this finding to the hypoalgesic effect of the emotional response that accompanies raised state aggression [22].

VVG exposure is thought to have a desensitizing effect not only on proximal pain but also on distal pain perception. In an event-related potential study [23], participants with no habitual experience in violent gaming showed reduced empathic responses to painful images after playing a VVG for 40 min. Participants with habitual violent gaming experience showed a desensitization effect to painful images already before gameplay. They also showed no additional decrease in empathic response to painful images after gameplay. The authors suggested that habitual violent gamers down-regulate their negative-emotional arousal to better perform in-game [23].

1.3 Hypotheses

Theoretically, then, players should become desensitized to aggression in their cognitive, physiological, and emotional responses after continuous exposure to VVG. For example, regarding desensitization in physiological response, Bartholow et al. reported that VVG exposure reduced event-related brain potentials which in turn predicted aggressive behavior in male adults, even when controlling for trait-aggression [11].

Therefore, three experimental studies tested the hypotheses that VVG exposure leads to reduced proximal (H1) and distal (H2) pain perception. In addition, VVG exposure is expected to increase pain tolerance (H3), increase aggressive behavior (H4), decrease physiological reactions to pain stimuli (H5), and decrease mood (H6).

Study 1 tested these hypotheses in a between-subjects lab experiment. Study 2 used the same basic design, trying to replicate findings with different methods to increase validity. Study 3 introduced the additional factor of immersion into the study design.

2 Study 1

Study 1[1] tested the relationship between VVG exposure and proximal pain perception, aggressive behavior, and mood. It was hypothesized that in contrast to playing a non-violent VG, playing a VVG decreases proximal pain perception, increases aggressive behavior, and decreases mood.

2.1 Methods

Participants. Participants ($N = 66$; 50% females; $M_{\text{age}} = 22.92$; $SD = 2.88$) were recruited at the University of Luxembourg. They indicated how much they played VG

[1] All three studies presented were accepted for ethics approval at the University of Luxembourg.

during typical weekdays, weekends, and holidays (1 = never; 2 = less than 1 h; 3 = 1–2 h; 4 = 2–3 h; 5 = more than 3 h). On average, participants played VG on a low to medium level ($M = 1.83$; $SD = .99$).

Pain Perception, Pain Tolerance, and Aggressive Behavior. Pain was induced using the cold pressor test (CPT). A container (size in cm: 60 x 40 x 18) was filled with cold water (4 °C) controlled by the immersion cooler Julabo FT200. To measure pain tolerance, participants held their hand up to the forearm in the cold water for as long as possible. Time was kept using a stopwatch. To measure pain perception, participants verbally rated their pain level every 15 s using a numerical rating scale (0 = no pain to 10 = worst possible pain, [24]). To measure aggressive behavior, they assigned a minimum time requirement in the CPT for the next participant. For ethical reasons, the maximum duration for the CPT was set to three minutes.

Target Games. Participants played both games on the Wii game console on a 46″ flatscreen. For the violent condition, *Manhunt 2* was chosen due to its high violence ratings. Participants controlled the game character, a patient who tries to escape from a closed psychiatric ward by killing people who get in his way. Participants in the non-violent condition played *Wii Sports Resort*, which includes a variety of sports games. Both games were chosen as they were easy to play but challenging.

Mood. Mood was assessed at two points in time with the positive and negative affect subscales of the PANAS [25] Each subscale comprises ten adjectives (e.g., active, guilty) that were rated on a 5-point scale (1 = not at all to 5 = extremely) on how strongly the person feels about each adjective. Internal consistency before gameplay was good for positive affect (Cronbach's $\alpha = .82$) and negative affect ($\alpha = .88$). The second measurement was done immediately after gameplay. The items were given in a different, randomized order. Again, the internal consistency was good for positive affect ($\alpha = .83$) and for negative affect ($\alpha = .89$).

Trait Aggression. To assess trait aggression, the Aggression Questionnaire [26] that includes the subscales for physical aggression (8 items), anger (6 items), and hostility (6 items) was used in its German version [27]. The items were rated on a 4-point scale (1 = I strongly disagree to 4 = I strongly agree). The combined scale for trait aggression showed good internal consistency ($\alpha = .80$).

Violent Video Games Preference. A novel five-item scale was designed for violent video game preference. Participants indicated how much they prefer and appreciate violent content in video games. Each item started with "I prefer games…" and were related to, among other factors, the motivation to intentionally behave antisocially in games (i.e., "…where I can hurt or kill others"), and to dominate others (i.e., "…that contain scenes of power and domination"). The scale had very good internal consistency ($\alpha = .85$).

Pain Sensitivity. To measure trait pain sensitivity, five items of the Pain Sensitivity Questionnaire (PSQ; [28]) were used. Participants were presented with five imaginary situations (e.g., "imagine that you burn your tongue on a hot drink") and rated the pain they would experience during these situations on a scale from 0 = no pain to 10 = worst possible pain. The PSQ had good internal consistency ($\alpha = .76$).

Empathy. To measure the relationship between empathy and pain perception, three of the four subscales of the German version of the Interpersonal Reactivity Index (IRI; [29, 30], namely empathic concern (e.g., "I often have tender, concerned feelings for people less fortunate than me"), perspective taking (e.g., "I sometimes try to understand my friends better by imagining how things look from their perspective"), and fantasy (e.g., "when I am reading an interesting story or novel, I imagine how I would feel if the events in the story were happening to me"). Each subscale was measured with four items on a 4-point-scale (1 = strongly disagree to 4 = strongly agree). The combined scale for trait-empathy had acceptable internal consistency ($\alpha = .67$).

Manipulation Check. To check if conditions were in fact perceived differently, participants rated two items on game content (e.g., "How brutal would you rate the game you just played"). Furthermore, they were asked about any difficulties with the game controls. Participants rated the items on a 5-point scale (1 = not at all to 5 = very much).

Procedure. After participants gave their informed consent, they were alternately assigned by gender to one of two conditions (violent condition vs. non-violent condition). Afterwards, participants provided demographic data, rated the PANAS items, indicated their gaming habits, and rated the IRI items, followed by the Trait Aggression Questionnaire and the PSQ. Next, participants played one of two video games according to their experimental condition for 15 min. After gameplay, participants first rated the PANAS items again and answered the control items for their game perception. Finally, the CPT was performed. Participants were told that they had to hold their hand in the cold water as long as possible. Next, as a measure of aggressive behavior, participants had to indicate a time requirement in the CPT for the next participant as a measure of aggressive behavior. Finally, participants were remunerated, thanked for their participation, and debriefed. The entire experiment lasted for about 30 min.

2.2 Results

All analyses were performed with IBM SPSS versions 25 and 27. The significance level was set at $p < .05$. Bonferroni correction for multiple comparisons was consistently applied in all three studies.

Control Variables. In the CPT, there was no gender difference for pain perception, $F(1, 60) = 1.49$, $p = .227$, $\eta^2 p = .02$. There were also no differences between conditions with regard to trait empathy, trait pain sensitivity, trait aggression, or gaming experience, $ps \geq .136$. Personality traits did not correlate with pain perception, or pain tolerance, $ps \geq .118$. Only VVG preference significantly correlated with trait empathy ($r = .25$, $p = .041$), trait aggression ($r = .40$, $p = .001$), and aggressive behavior ($r = .32$, $p < .001$).

The manipulation check confirmed that the game conditions were perceived differently. Participants rated the violent game as more brutal ($M = 4.27$; $SD = 1.01$) than the non-violent game ($M = 1.00$; $SD = 0.00$), $F(1, 64) = 347.53$, $p < .001$, $\eta^2 = .84$.

Furthermore, VVG preference was correlated with change in positive affect (T2-T1) ($r = .27$, $p = .031$), pain tolerance ($r = .28$, $p = .026$), and proximal pain perception ($r = -.28$, $p = .025$).

Hypotheses. A one-way ANOVA with condition as between-subjects variable (violent vs. non-violent condition) and proximal pain perception (pain ratings during CPT) as dependent variable tested H1. However, there was no significant effect, $F(1, 62) < 0.01$, $p = .974$, d < .01. Next, a one-way ANOVA with time in the CPT as dependent variable tested H3. Again, there was no significant effect, $F(1, 64) = 1.97$, $p = .166$, d = .35. Means and standard deviations are displayed in Table 1.

To test H4, a one-way ANOVA was calculated with condition as between-subjects factor and time in the CPT allotted to the next participant as dependent variable, but did not reveal a significant effect, $F(1, 64) = 0.04$, $p = .835$, $d = .05$.

Finally, two mixed-measures ANOVA tested H6. Again, condition served as between-subjects factor, and positive affect (PA score at T1 vs. PA score at T2) and negative affect (NA score at T1 vs. NA score at T2) served as within-subjects factors, respectively. Regarding positive affect, there was no significant within-subjects effect or between-subjects effect, $p \geq .10$. However, the interaction between condition and PA score was significant, $F(1, 60) = 23.11$, $p < .001$, $\eta^2p = .28$. Contrasts revealed that for participants who played the violent game there was a significant decrease in positive affect from T1 to T2, $F(1, 28) = 14.94$, $p = .001$, $\eta^2p = .35$, see Fig. 1. In contrast, participants who played the non-violent game had a significant increase in positive affect, $F(1, 32) = 7.31$, $p = .011$, $\eta^2p = .19$. For the negative affect, there was a significant within-subjects effect, $F(1, 62) = 13.80$, $p < .001$, $\eta^2p = .18$, and a significant between-subjects effect, $F(1, 62) = 13.07$, $p = .001$, $\eta^2p = .17$. However, the interaction between condition and the within-subjects factor of NA score was also significant, $F(1, 62) = 24.45$, $p < .001$, $\eta^2p = .28$. Separate analysis showed that the negative affect increased for participants who played the violent game, $F(1, 30) = 22.62$, $p < .001$, $\eta^2p = .43$. This was not the case for participants who played the non-violent game, $F(1, 32) = 1.81$, $p = .188$, $\eta^2p = .05$.

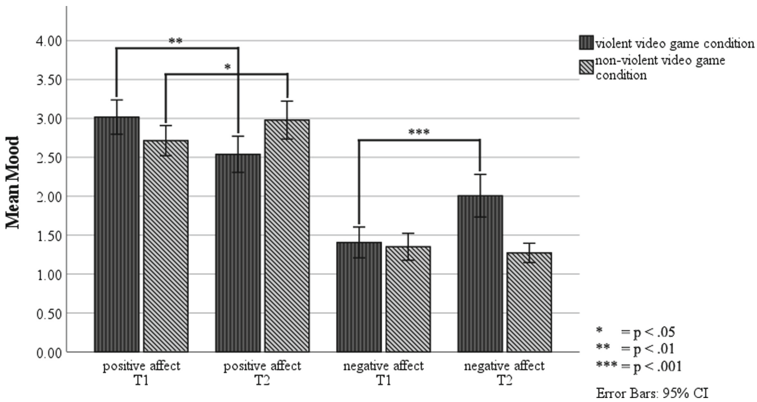

Fig. 1. Positive and negative affect before (T1) and after (T2) gameplay in the violent video game condition and the non-violent video game condition in study 1.

Table 1. Means and standard deviations for positive and negative affect at T1 and T2 as well as proximal pain perception and pain tolerance in the two game conditions in study 1.

Measure	Violent condition		Non-violent condition	
	M	*SD*	*M*	*SD*
Positive affect T1	3.06	0.60	2.72	0.55
Positive affect T2	2.52	0.55	2.98	0.69
Negative affect T1	1.44	0.50	1.35	0.49
Negative affect T2	1.99	0.68	1.27	0.35
Proximal pain perception	6.91	1.65	6.92	1.61
Pain tolerance (with exclusions)	88.65	65.48	96.41	71.49
Pain tolerance (without exclusions)	101.45	81.50	133.42	102.52
Aggressive Behavior (time allotted to next participant in CPT)	48.94	55.41	46.55	35.55

To test if gender influenced the effect of VVG exposure on pain tolerance, a two-way ANOVA was calculated with gender and condition (violent vs. non-violent) as between-subjects factors and time in the CPT as dependent variable. Results did not show any significant main or interaction effects, $F\text{s} \leq .82$, $p\text{s} \geq .370$, $\eta^2 p \leq .02$.

Furthermore, an additional ANCOVA was run to test for the effect of condition (violent vs. non-violent condition) on pain tolerance (time in the CPT), including pain sensitivity (PSQ score) as covariate. The main effect of condition on pain tolerance did not reach the level of significance, $F(1,54) = .02$, $p = .884$, $\eta^2 p < .001$. Pain sensitivity was also not a significant predictor of pain tolerance, $F(1, 54) = 1.79$, $p = .187$, $\eta^2 p = .03$. Means and standard deviations are displayed in Table 2.

Table 2. Means and standard deviations for pain tolerance, PSQ score, as well as Pain tolerance at the covariate mean level of PSQ

Measure	Violent condition		Non-violent condition	
	M	*SD*	*M*	*SD*
Pain tolerance	90.40	65.85	96.41	71.49
Pain tolerance at PSQ = 3.88	91.98	12.49	94.65	13.17
PSQ score	3.94	1.65	3.59	1.40

2.3 Discussion

As expected, there was a significant effect of VVG play on mood, decreasing positive affect and increasing negative affect. However, VVG play did not significantly affect pain tolerance in the CPT, proximal pain perception, or aggressive behavior. Can the absence of a desensitization effect be replicated, or was it just due to the use of inappropriate methods?

3 Study 2

Study 2 included different measures for pain and aggressive behavior. Pain tolerance and perception were assessed with the Medoc Pathway Pain and Sensory Evaluation System (see below). Heart rate variability (HRV) indicated the activity of the autonomic nervous system, with higher HRV relating to greater pain inhibition capacity [31]. The Competitive Reaction Time Task (CRTT) measured aggressive behavior.

3.1 Methods

Participants. A total of 64 participants ($M_{age} = 27.57$; $SD = 11.57$) took part in study 2 (50% females) at the University of Luxembourg. As in study 1, participants indicated how much they played video games ($M = 2.22$; $SD = 1.23$). They also rated their gaming experience (1 = not experienced, 2 = somewhat inexperienced, 3 = somewhat experienced, 4 = experienced). On average, participants were experienced on a medium level ($M = 2.38$; $SD = 1.11$). Again, participants rated the five items for violent video game preference ($\alpha = .91$).

Pain Tolerance and Proximal Pain Perception. To assess pain tolerance, pain stimuli were applied via a heat thermode. There were 9 trials, each lasting five seconds with an increase of 1 °C per trial. The first heat stimulus was set at 42 °C and the maximum heat stimulus was set at 50 °C. Between trials, the thermode immediately cooled to 32 °C. For each trial, participants rated their perceived pain on a 10-point numerical rating scale (0 = no pain and 10 = worst possible pain) [24]. If a participant rated a pain stimulus as 10, the task was immediately discontinued. Individual pain tolerance was the sum of the trials the participants had completed until they gave a maximum pain rating (10) or until all 9 trials were completed.

Competitive Reaction Time Task. The CRTT is a flexible and powerful tool to assess the effect of aggression-eliciting stimuli [32]. For the task, participants were told that they would play a game against a pretend opponent who, unbeknownst to the participants, did not actually exist. In each of the nine rounds of the task, participants were told to press a key as quickly as possible when the green box on the monitor turned red. If the opponent was faster, the participants were exposed to a noise blast between 50 and 105 decibels through headphones. Prior to each round, participants indicated the amplitude and duration of the noise blast for their opponent if the opponent lost the round (aggressive behavior). The number of wins and defeats was determined in advance without the participants knowing. In the first round, the participants always lost.

Heart Rate Variability. HRV was measured with two electrocardiography electrodes using a heart rate belt connected via Bluetooth to an iPad. One electrode was placed under the upper right clavicle and the other electrode was placed above the hip on the left side of the body. Data was collected with the app HRV Logger and transferred to Artiifact [33] for further analyses. Here, the root mean square of successive differences (RMSSD) for the time domain and the absolute power of the high frequency-band (HF; 0.15–0.40 Hz) for the frequency domain were used [34]. RMSSD reflects beat-to-beat HRV and is robust against influential factors like respiration and is correlated to HF. RMSSD and HF are reliable measures for parasympathetic activity [34], which typically indicates the bodily functions when a person is at rest. Baseline HRV was assessed during the five minutes it took participants to answer questionnaire items, during gameplay, and during the pain perception task.

Target Games. Participants played the same games as in study 1 for 15 min.

Mood, Trait Aggression, Empathy, Pain Sensitivity. Violent Video Game Preference. Study 2 used the same measures as in study 1. Mood was again assessed at two time points with the PANAS scales [25]. The internal consistency before gameplay was good for positive affect ($\alpha = .85$) and acceptable for negative affect ($\alpha = .67$). For the post-measurement, the internal consistency was excellent both for positive affect ($\alpha = .91$) and negative affect ($\alpha = .91$). The German version of the Aggression Questionnaire [27] measured trait-aggression which showed very good internal consistency ($\alpha = .85$). The combined scale for trait empathy that included the three subscales for emotional concern, fantasy, and perspective taking from the German version of the IRI [30] had good internal consistency ($\alpha = .82$). With regard to participants' inherent pain sensitivity, the PSQ-scale [28] showed an acceptable internal consistency ($\alpha = .67$). Finally, the violent video game preference scale had excellent internal consistency ($\alpha = .91$).

Manipulation Check. Game perception was measured with four novel items (e.g., "How brutal would you rate the game you just played?"; $\alpha = .87$). Another item tested if game mechanics or the effects of the controls of the game influenced participants (i.e., "How difficult was it for you to control the game?"). Items were rated on a 4-point scale (1 = not at all to 4 = very much).

Procedure. After participants gave informed consent, they provided demographic information and rated the items of the questionnaire. In the meantime, baseline HRV was assessed. Then, participants were randomly assigned to one of the two conditions (violent condition vs. non-violent condition) and played for 15 min. During gameplay, the second HRV measurement was recorded. After gameplay, participants first rated the PANAS items again and filled in the control items for game perception. Then, the task for pain perception and tolerance was applied together with the third HRV measurement. Next, participants completed the CRTT task. Finally, they were remunerated, thanked for their participation, and debriefed. The entire study took about 45 min.

3.2 Results

Control Variables. There were no significant group differences for trait aggression, empathy, pain sensitivity, or for the effect of game controls $ps \geq .102$. In contrast, there was a significant difference between the two conditions on game perception, Welch's $F(1, 32.36) = 240.64$, $p < .001$, $\eta^2 = .80$. As expected, participants rated the VVG as significantly more brutal, more morally questionable, felt more guilt, and felt that they dealt out more pain in the game ($M = 2.85$; $SD = 0.66$) than the non-violent game ($M = 1.02$; $SD = 0.10$).

In the CRTT, males ($M = 5.75$, $SD = 1.92$) behaved significantly more aggressively than females ($M = 3.71$, $SD = 2.45$), $F(1, 62) = 13.71$, $p < .001$, $\eta^2 = .18$. There was also a gender effect for duration in the CRTT, with males ($M = 5.05$; $SD = 2.19$) choosing longer durations of noise blasts than females ($M = 3.36$, $SD = 2.18$), $F(1, 62) = 9.59$, $p = .003$, $\eta^2 = .13$. However, no other gender effect was significant, $ps \geq .115$.

Aggressive behavior (CRTT intensity) was correlated with gaming experience, $r = .35$, $p = .005$, trait aggression, $r = .29$, $p = .021$, and pain perception, $r = -.25$, $p = .043$. Interestingly, trait empathy was positively related to gaming experience, $r = .35$, $p = .005$.

Violent video game preference was positively correlated with intensity ($r = .43$, $p < .001$) and duration ($r = .49$, $p < .001$) in the CRTT only, but not to proximal pain perception, mood, HRV, or pain tolerance ($ps \geq .124$).

Hypotheses. To test H3, two one-way ANOVAs were calculated with game condition as independent variable, and pain perception (i.e., mean of pain ratings) and pain tolerance (i.e., sum of pain induction trials) as dependent variables, respectively. Game conditions did not differ for pain perception or pain tolerance, $ps \geq .520$. Means and standard deviations are shown in Table 2.

To test H4, a one-way ANOVA was calculated with condition as independent variable, intensity in the CRTT, and duration in the CRTT as dependent variables. There was no significant difference between conditions for CRTT intensity or CRTT duration, $ps \geq .620$ (Table 3).[2]

Table 3. Means and standard deviations in the two game conditions for CRTT intensity, CRTT duration, pain perception, and pain tolerance in study 2.

Measure	Violent condition		Non-violent condition		Group Differences		
	M	*SD*	*M*	*SD*	Test	*p*	η^2
CRTT Intensity	4.88	2.72	4.58	2.10	$F = 0.25$	.621	< .01
CRTT Duration	4.34	2.57	4.07	2.09	$F = 0.22$	.641	< .01
Pain Perception	5.28	1.82	5.00	1.58	$F = 0.42$	.518	.01
Pain Tolerance	8.22	1.69	8.44	0.91	$F = 0.42$	.520	.01

[2] As noted by a reviewer, as there were significant gender differences in the CRTT gender should be included as a covariate. Therefore, additional ANCOVAs were computed with gender as a covariate. Again, there were no significant effects of VVG exposure on aggressive behavior in the CRTT (p ≥ .771).

To test H5, a mixed ANOVA was calculated with condition as between-subjects variable, and RMSSD and HF as within-subjects variables. There was no significant between-subjects effect, $F(1, 39) = 2.89$, $p = .097$, $\eta^2p = .07$, but a significant within-subjects effect for RMSSD, $F(1.72, 66.99) = 8.92$, $p = .001$, $\eta^2p = .19$. Mauchly's test of sphericity was significant (Mauchly's $W = .84$, $p = .033$) and therefore the Greenhouse-Geisser correction ($\varepsilon = .86$) was applied. Within-subjects contrasts confirmed a significant decrease in RMSSD from baseline ($M = 44.18$; $SD = 26.41$) to RMSSD during gameplay ($M = 34.31$; $SD = 19.94$), $F(1, 39) = 7.82$, $p = .008$, $\eta^2p = .17$, and from gameplay to pain perception ($M = 45.57$; $SD = 21.81$), $F(1, 39) = 20.31$, $p < .001$, $\eta^2p = .34$. More importantly, there was a significant interaction effect between condition and RMSSD change from gameplay to pain perception task. Only participants who played the VVG had a significant increase in RMSSD from gameplay to pain perception task, $F(1, 39) = 5.24$, $p = .028$, $\eta^2p = .12$ (see Fig. 2). For HF, there was also a significant within-subjects effect for HF, $F(2, 78) = 7.15$, $p = .001$, $\eta^2p = .16$. During gameplay ($M = 0.04$, $SD = 0.02$), there was a significant decrease in HF compared to baseline ($M = 0.04$, $SD = 0.03$), $F(1, 39) = 4.45$, $p = .041$, $\eta^2p = .10$, whereas HF significantly increased from gameplay to the pain perception task ($M = 0.05$; $SD = 0.03$), $F(1, 39) = 15.62$, $p < .001$, $\eta^2p = .29$ (see Fig. 3). There was no significant interaction effect, $F(2, 78) = 1.36$, $p = .262$, $\eta^2p = .03$ or between-subjects effect, $F(1, 39) = 2.25$, $p = .142$, $\eta^2p = .06$.

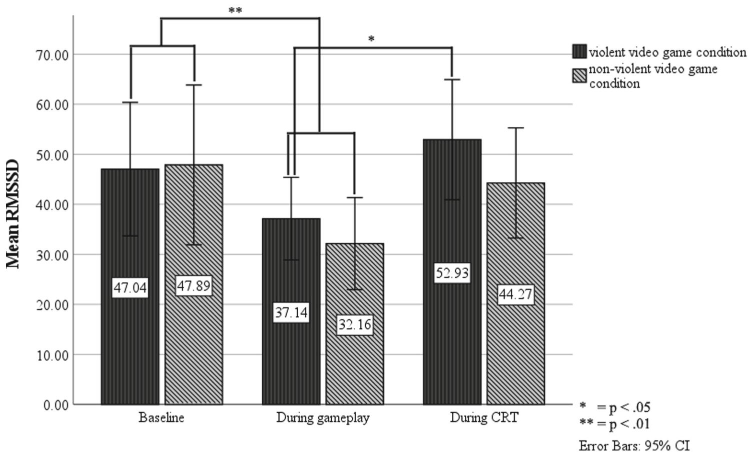

Fig. 2. Mean RMSSD in the VVG condition and the non-violent video game condition at baseline (T1), during gameplay (T2) and during CRTT (T3) in study 2.

Finally, two mixed-measures ANOVA tested H6. Condition served as between-subjects factor, and positive affect (PA score at T1 vs. PA score at T2) and negative affect (NA score at T1 vs. NA score at T2) were the within-subject factors, respectively. For positive affect, only the interaction between condition and PA score was significant, $F(1, 62) = 4.17$, $p = .045$, $\eta^2p = .06$, but separate analyses did not reveal any significant effects, $ps \geq .130$. For negative affect, there was a significant within-subjects effect, $F(1, 62) = 5.50$, $p = .022$, $\eta^2p = .08$, indicating a significant increase in negative affect from

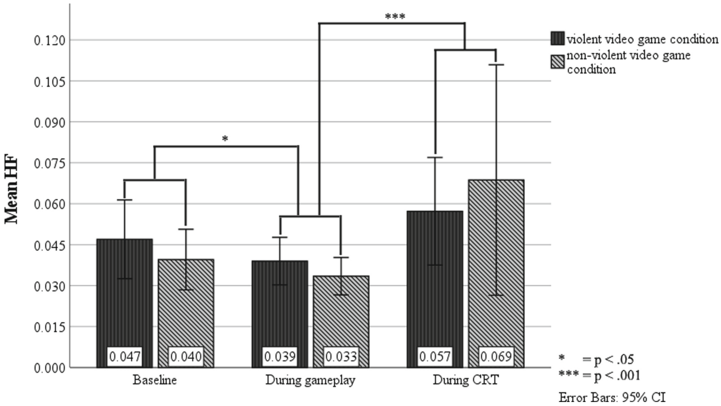

Fig. 3. Mean HF in the VVG condition and the non-violent video game condition at baseline (T1), during gameplay (T2) and during CRTT (T3) in study 2.

T1 ($M = 1.32$; $SD = 0.33$) to T2 ($M = 1.48$; $SD = .63$), and a significant between-subjects effect, $F(1, 62) = 14.33$, $p < .001$, $\eta^2 p = .19$. More importantly, the interaction effect between condition and the within-subjects factor of NA score was significant, $F(1, 62) = 10.58$, $p = .002$, $\eta^2 p = .15$. Separate analysis showed that participants who played the violent game showed a significant increase in negative affect from T1 ($M = 1.32$; $SD = 0.33$) to T2 ($M = 1.76$; $SD = 0.78$.), $F(1, 31) = 8.65$, $p = .006$, $\eta^2 p = .22$, see Fig. 4. In the non-violent game condition, there was no significant within-subjects effect for NA score from T1 ($M = 1.27$; $SD = .27$) to T2 ($M = 1.20$; $SD = 0.20$), $F(1, 31) = 2.19$, $p = .149$, $\eta^2 p = .07$.

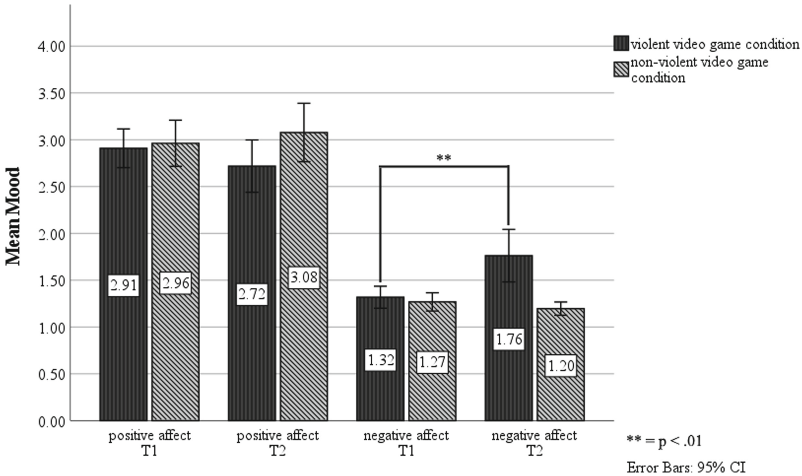

Fig. 4. Positive affect and negative affect in the VVG condition and the non-violent video game condition at the beginning of the experiment (T1) and after gameplay (T2) in study 2.

3.3 Discussion

Study 2 confirmed the results of study 1, using different outcome measures. There were no significant effects of VVG play on aggressive behavior, pain perception, or on pain tolerance. Again, VVP play lead to increased negative effect. In study 2, however, VVG play had no influence on positive affect. Since the level of immersion in the game mediates the effects of VVG [35], study 3 was conducted to replicate the results of the first two studies and test the level of immersion as an additional factor.

4 Study 3

The level of immersion in the game mediates the effects of VVG [35] and influences pain sensitivity [21]. Therefore, participants played either a violent-immersive, a non-violent-immersive or a non-violent-non-immersive video game in study 3.

4.1 Methods

Participants. Study 3 involved 75 participants ($M_{age} = 27$; $SD = 10.06$; 42% females). Participants indicated to play VG on a medium level ($M = 2.22$; $SD = 1.23$).

Pain Perception. To measure distal pain perception, participants rated the level of pain they perceived in pictures. The pictures were pilot tested with $N = 50$ student participants. Each of the 15 neutral pictures and 17 pain-related pictures of the IAPS (International Affective Picture System; [36]) were rated on a numerical pain rating scale from 0 (=no pain) to 10 (=worst possible pain) [24]. From these pictures, 10 neutral ($\alpha = .76$) and 10 pain-related pictures ($\alpha = .92$) with the highest reliabilities were chosen. A dependent sample t-test showed that the pain-related pictures were rated as significantly more painful ($M = 7.11$, $SD = 1.89$) than the neutral pictures ($M = 0.30$, $SD = 0.52$), $t(49) = 26.01$, $p < .001$, $d = 4.91$. In study 3, participants rated these 20 items in randomized order on the same numerical pain rating scale used in the pilot study. Proximal pain perception was again measured with the CPT (see study 1).

Heart Rate Variability. Again, there were three heart rate measurement times during the study. Data from T1 served as a baseline, data from T2 were collected during gameplay, and data from T3 were recorded during the CPT. Due to technical difficulties, T1 data for four participants could not be used.

Mood, Trait Aggression, Pain Sensitivity. Study 3 used the same measures as studies 1 and 2. Mood was again assessed at two timepoints with the PANAS [25]. In study 3, the internal consistency at t1 was very good for positive affect ($\alpha = .86$) and acceptable for negative affect ($\alpha = .63$). For t2, the internal consistency ranged from very good to excellent for the positive ($\alpha = .92$) and negative affect ($\alpha = .87$). The two subscales for anger and hostility from the German version of the Aggression Questionnaire [34] were combined to general trait aggression, which showed very good internal consistency ($\alpha = .85$). The PSQ was again used to measure participants' inherent pain sensi-tivity [35] and had acceptable internal consistency ($\alpha = .69$).

Target Games. In the violent condition, *Sniper Elite III* for the PlayStation4 was used due to its high violence ratings (age rating label “PEGI 18”) and high level of immersion. In *Sniper Elite III*, the player shoots down enemy WW2 soldiers as a sniper. The game contains explicit graphical representations of extreme violence and blood. In the non-violent immersive condition, the racing game *Mario Kart 8* was played on the Wii U console. In the non-violent non-immersive condition, *Yoshi’s Fruit Cart* for the Wii U was chosen as it is neither violent nor immersive. The game required participants to draw line paths with the Stylus so that the game character Yoshi can collect points (i.e., fruits). All the three games had simple controls that were easy to explain to participants.

Empathy. Trait empathy was measured using the two subscales for emotional concern and perspective taking from the German version of the IRI [30]. The combined scale had good internal consistency ($\alpha = .73$). In addition to the IRI, media-based empathy (MBE; [37]) was used to measure the ability of participants to feel empathy for fictitious characters (4 items; e.g., “Media reports about what is happening in the world are very close to me.”), as well as their ability to immerse themselves in VG (5 items; e.g., “I experience very strong feelings when I play good video games.”). The items were rated on a five-point Likert scale (1 = I strongly disagree to 5 = I strongly agree; $\alpha = .83$).

Manipulation Check. Game perception was measured with five items on competition, frustration, time pressure, brutality, and immersion. The items (e.g., “how brutal would you rate the game you just played?”) were rated on a 5-point scale (1 = not at all to 5 = very much). The scale showed good internal consistency ($\alpha = .74$).

Procedure. After participants gave informed consent, the electrodes for HRV assessment were applied. Then, questions on demographics, trait empathy, trait pain sensitivity were answered, and the PANAS items rated. Next, participants were randomly assigned to one of the three game conditions. After familiarizing themselves with the game controls, they played for 15 min. Then, participants rated the PANAS items again and the items for trait aggression. Next, the CPT was administered. Then, the pictorial stimuli were shown to assess distal pain perception. Finally, participants were remunerated, thanked and debriefed. The experiment took about 45 min.

4.2 Results

Control Variables. There were no significant differences between conditions for trait empathy, trait aggression, media-based empathy, or pain sensitivity, $p\text{s} \geq .37$. Also, there were no differences between the genders, $p\text{s} \geq .40$.

Hypotheses. The between-subjects ANOVA that tested the differences between the three game conditions for proximal pain perception (H1) showed no significant effect, $F(2, 72) = 0.25, p = .783, \eta^2\text{p} = .01$. Neither the ANOVA on distal pain perception (H2) nor the comparison of conditions in terms of pain tolerance (H3) revealed significant effects, $p \geq .433$. Means and standard deviations are displayed in Table 4.

Table 4. Means and standard deviations in the different game conditions for proximal pain perception, distal pain perception, and pain tolerance in study 3.

Measure	Violent condition		Non-violent-immersive condition		Non-violent-non-immersive condition	
	M	*SD*	*M*	*SD*	*M*	*SD*
Proximal Pain Perception	6.48	1.12	6.30	2.21	6.63	1.42
Distal Pain Perception	7.87	1.74	8.10	0.99	7.81	1.24
Pain Tolerance	91.80	58.22	100.60	62.62	78.20	63.13

Next, two repeated-measures ANOVAs tested if VVG exposure influenced mood (H6). Condition served as between-subjects factor, whereas positive affect (PA score at T1 vs. PA score at T2) and negative affect (NA score at T1 vs. NA score at T2) were the within-subject factors, respectively. No significant effects were found, $p \geq .085$. However, separate analyses showed that there was a significant decrease in positive mood for participants who played the violent game, $F(1, 23) = 8.87$, $p = .007$, $\eta^2 p = .28$, see Fig. 5. There was no significant difference in mood after playing the non-violent-immersive or the non-violent-non-immersive video game, Fs $\leq .33$, ps $\geq .592$, $\eta^2 p \leq .01$. For negative affect, there was only a significant interaction effect, $F(2, 71) = 6.79$, $p = .002$, $\eta^2 p = .16$. Separate analysis showed a significant increase in negative affect for participants who had played the violent game, $F(1, 23) = 12.51$, $p = .002$, $\eta^2 p = .35$, which was not the case in the other conditions, Fs ≤ 1.39, $p \geq .249$, $\eta^2 p \leq .06$. Means and standard deviations are displayed in Table 5.

Two additional ANCOVAs with pain sensitivity (PSQ score) as covariate were calculated. There were no significant effects on pain tolerance (time in the CPT) or proximal pain perception, $p \geq .15$. Pain sensitivity did not predict pain tolerance, $F(26, 26.70)$, $p = .970$, $\eta^2 p = .49$, but proximal pain perception, $F(26, 29.97) = 2.58$, $p = .007$, $\eta^2 p = .691$.

To test H5, a mixed ANOVA was calculated with RMSSD and with HF as within-subjects factors and condition as between-subjects factor. For RMSSD, Mauchly's test of sphericity was significant ($p < .001$) and so the Greenhouse-Geisser correction was applied ($\varepsilon = .83$). The analysis revealed a significant within-subjects effect for RMSSD, $F(1.66, 119.49) = 5.19$, $p = .011$, $\eta^2 p = .07$, with a significant increase in RMSSD from gameplay ($M = 39.17$; $SD = 20.78$) to when participants did the CPT ($M = 43.70$; $SD = 22.83$), $F(1, 72) = 5.66$, $p = .020$, $\eta^2 p = .07$. However, there was no significant between-subjects effect or interaction effect, $p \geq .430$ (see Fig. 6). For HF, Mauchly's test of sphericity was significant ($p < .001$) and so the Greenhouse-Geisser correction was applied ($\varepsilon = .77$). The analysis revealed no significant effects $p \geq ..083$.

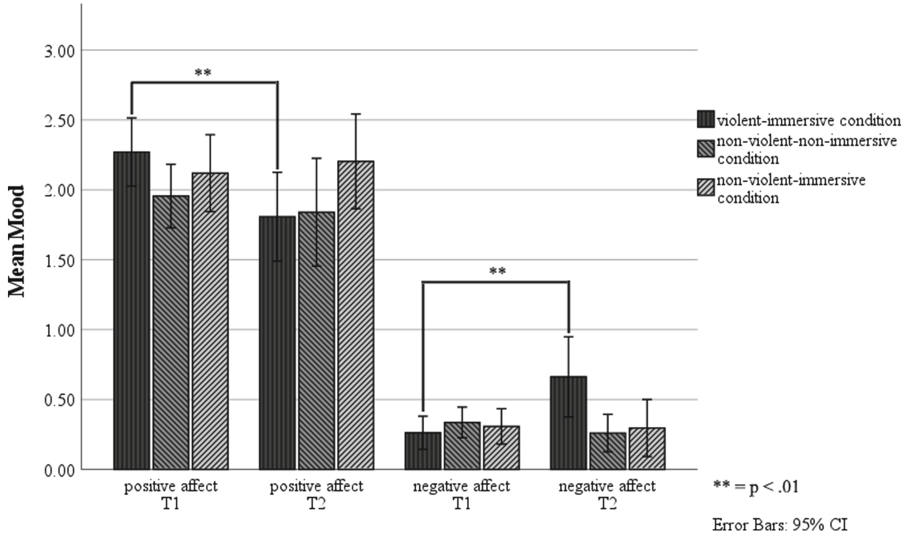

Fig. 5. Positive affect and negative affect in the three game conditions at the beginning of the experiment (T1) and after gameplay (T2) in study 3.

Table 5. Means and standard deviations for positive and negative affect at T1 and T2 across the three conditions in study 3.

Measure	Violent condition		Non-violent-immersive condition		Non-violent-non-immersive condition	
	M	*SD*	*M*	*SD*	*M*	*SD*
Positive affect T1	2.27	0.58	2.12	0.67	1.96	0.55
Positive affect T2	1.81	0.75	2.20	0.82	1.84	0.93
Negative affect T1	0.26	0.28	0.31	0.28	0.34	0.27
Negative affect T2	0.66	0.68	0.30	0.50	0.26	0.33

4.3 Discussion

Again, VVG play significantly affected mood, leading to decreased positive affect and increased negative affect. However, like study 1 and 2, there were no significant effects of VVG play on pain-related indicators. In addition, level of immersion had no effect on the results for the outcome variables.

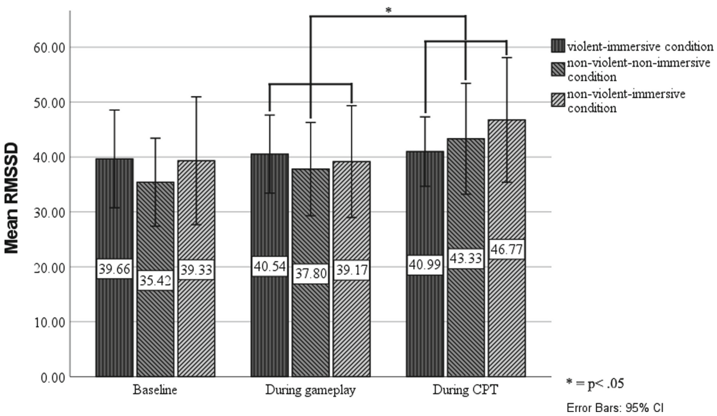

Fig. 6. Mean RMSSD at baseline, during gameplay, and during the CPT across the three conditions in study 3.

5 General Discussion

Does playing VVG increase aggression while numbing and desensitizing pain? Three lab experiments tested the effects of VVG on pain-related indicators and aggressive behavior. The empirical results of the present studies are clear: there were no significant effects of direct VVG exposure on behavioral data of aggressive behavior, pain tolerance, or pain perception. In contrast, the VVG preference of participants was associated with higher pain tolerance and lower proximal pain perception in study 1, and VVG preference was associated with higher trait aggression and higher aggressive behavior in study 2. We may speculate that people with higher trait aggression and those who behave more aggressively are drawn more toward VVG and in-game depictions of violence. Notwithstanding this, at least the present findings suggest that VVG exposure itself does not lead to an increase in aggressive behavior or to desensitization.

All three studies confirmed the negative effect that VVG play has on mood. Compared to a nonviolent VG participants in the VVG condition felt significantly worse after playing—their positive affect decreased, while negative affect increased. This finding is in line with prior research that showed VVG effects on mood [15, 38].

Pain is a complex and multidimensional construct, modulated by individual, physiological, and contextual factors [2]. Based on the findings from the present studies, it appears that physiological factors as well as personality traits dominate pain responses. Perhaps the gaming episode in the present studies was too weak as contextual factor to show any effect on pain perception or pain tolerance. In contrast, individual factors affected pain tolerance, pain perception, and aggressive behavior. Significant gender differences were found on aggressive behavior in study 1, with males being more aggressive than females. Personality traits (i.e., trait aggression, trait pain sensitivity, and violent video game preference) were related to pain tolerance, pain perception, and positive affect (study 1), and to aggressive behavior (study 2). Although some authors assume that situational factors influence aggression more than personality factors [39], this was not the case in the present studies. Similar to the presented results, other studies also show that personality factors rather than game violence are associated with aggression [40]. Markey and Markey concluded that personality factors and personal predispositions moderate negative VVG effects, thus making some individuals more vulnerable to VVG effects than others [41]. In addition, personality factors are related to both VVG preferences and VVG exposure [42, 43] and can moderate physiological reactions to VVG exposure [44]. Thus, when confronted with VG violence, individuals without these predispositions should not show an increase in aggression or desensitization.

In study 2, HRV (RMSSD and HF) significantly decreased from baseline to gameplay and increased again to during the CRTT across both conditions. In study 3, HRV (RMSSD) significantly increased from gameplay to the CPT for participants across all gaming conditions. This shows that participants experienced decreased parasympathetic activity during gameplay, but higher parasympathetic activity after gameplay, possibly representing greater tension during and a reduction in tension after gameplay. This is in line with previous research showing an increase in parasympathetic activity after VVG play [45]. However, there were no significant differences between participants playing a violent or a non-violent game. Furthermore, research has shown that parasympathetic activity is decreased during the experience of pain [31]. This was also not the case in the present study as RMSSD increased during the CPT for participants in study 3. It is unclear why playing a VG decreased parasympathetic activity in study 2, and if HRV increased during the CRTT due to the prior gaming effects or due to the nature of the CRTT or other variables. Future studies should incorporate explicit measures that in addition to objective physiological measures to disentangle these findings, assess the perceived physiological states of participants.

Playing a VG can indeed lead to a decrease in pain perception [21, 22, 46, 47]. It is possible that the assumed distractive, hypoalgesic effects of playing VG is independent of violent content. In the presented studies, however, there was no control condition in which participants did not play a VG. Therefore, it cannot be ruled out that playing VG generally leads to desensitization to pain. Based on the present findings, we can only conclude that the content of the game, violent or not, has no pain-related effects.

Regarding limitations, the large variability in the present student-dominated samples with only a few VG enthusiasts may have contributed to the lack of pain-related effects detected. Sample sizes with few “hardcore gamers” might not be sufficient to detect small effects that would be expected for the desensitization effects of VVG [10].

Another limitation of the present studies lies in their design. The games used in the present studies varied greatly regarding content, game design, graphical appearance, and game controls. Future studies should limit these potentially influential factors by using more comparable target games, or ideally, by using passages (nonviolent vs. violent) from the same game. Moreover, although some authors have argued that even short-term exposure to VVG can lead to desensitization [17], playing a violent game for only 15 min might be too short to influence later aggression, pain perception, or pain tolerance measures. Future studies should therefore increase playing time to increase the generalizability and reliability of findings.

In summary, the present results are consistent with findings that exposure to VG violence does not have a desensitization effect on aggression [48, 49], pain perception

[50, 51], or empathic response [52]. However, the effects of violent games may be moderated by specific personality factors not tested here that make people more susceptible to the effects, increasing the likelihood of desensitization, aggression and pain tolerance, while at the same time decreasing pain perception and empathic concern. Future studies should therefore take a closer look into the moderating role of personality factors on the effects of (violent) video games on the players.

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