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The Influence of Violent and Nonviolent Computer Games on Implicit Measures of Aggressiveness

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We examined the causal relationship between playing violent video games and increases in aggressiveness by using implicit measures of aggressiveness, which have become important for accurately predicting impulsive behavioral tendencies. Ninety-six adults were randomly assigned to play one of three versions of a computer game that differed only with regard to game content (violent, peaceful, or abstract game), or to work on a reading task. In the games the environmental context, mouse gestures, and physiological arousal—as indicated by heart rate and skin conductance—were kept constant. In the violent game soldiers had to be shot, in the peaceful game sunflowers had to be watered, and the abstract game simply required clicking colored triangles. Five minutes of play did not alter trait aggressiveness, yet an Implicit Association Test detected a change in implicit aggressive self-concept. Playing a violent game produced a significant increase in implicit aggressive self-concept relative to playing a peaceful game. The well-controlled study closes a gap in the research on the causality of the link between violence exposure in computer games and aggressiveness with specific regard to implicit measures. We discuss the significance of importing recent social–cognitive theory into aggression research and stress the need for further development of aggression-related implicit measures. Aggr. Behav. 35:1–13, 2009.

Keywords: aggressiveness; aggression; implicit self-concept; Implicit Association Test; Single-Target Implicit Association Test

Violent computer games such as first-person shooters (e.g., "Counterstrike") have repeatedly raised the suspicion of parents, teachers, politicians, and scientists alike. Given the increasingly realistic portrayals of violence and the substantive training of (virtual) aggressive acts in these games rather than the passive observation of violence in movies, many have been alarmed by the wide-spread use of these games [Smith et al., 2003]. The discussion resembles the previous debate on the effects of passive violence exposure in TV and movies [Bushman and Anderson, 2001], and in line with psychological theories on aggression and based on empirical evidence, similar conclusions have been drawn regarding side effects of violence exposure in computer games: Most authors would conclude that a clear consensus has been reached that a noticeable causal influence of playing violent video games on aggressive behavior and dispositions—of young people in particular—exists [Carnagey and Anderson, 2004]. Nevertheless, the number of studies establishing a causal link between aggressiveness and interactive media such as violent computer games remains relatively small in comparison to studies on passive media exposure. Evidence is particularly scarce with regard to whether latency-based measures of cognition, so-called implicit measures, are useful for detecting any changes in aggressive cognition as a consequence of exposure to video games.

Implicit measures may be particularly suited to uncover the processes how playing violent and nonviolent video games affects a player's automatic cognitions. Implicit dispositions could play a key role in spontaneous and impulsive aggressive tendencies in the short and long run. Conventional wisdom holds that a substantial part of aggressive behavior is carried out in the absence of cognitive

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resources or in situations where people lack behavioral control (e.g., after alcohol consumption). Obviously, aggression does not always reflect actions in line with one's conscious reasoning or explicitly endorsed attitude toward aggression and violence. Those dispositions that relate to less-controlled aspects of human behavior, rather than deliberate behavior and intended actions, may be addressed by the term "implicit personality" [Banse and Greenwald, 2007; Perugini and Banse, 2007].

The Media Violence Exposure–Aggression Link

Psychological theories that predict increases in aggression after (repeated) media violence exposure are plentiful. Not a single psychological theory predicts positive outcomes, neither in the short nor in the long run—except for the catharsis hypothesis which until now suffers from empirical confirmation [Bushman et al., 1999]. Among the most important mechanisms for short-term effects are (1) associative priming of existing aggressive beliefs, well-encoded scripts, and angry emotional reactions [Berkowitz, 1993], (2) emotional arousal upon observation of violence and excitation transfer [Zillmann, 1978], and (3) simple mimicry of aggressive scripts [Huesmann and Kirwil, 2007]. Long-term effects are most prominently considered to be a consequence of (1) observational learning of new social scripts [Huesmann, 1988], (2) development of beliefs supporting aggression or hostile schemas that accompany expectations in social interactions [Anderson and Godfrey, 1987; Huesmann and Kirwil, 2007], as well as (3) conditioning of aggression-promoting emotions [Bushman and Huesmann, 2006]. Long-term emotional desensitization to violent scenes may also occur [Carnagey and Anderson, 2004].

Empirical evidence in favor of the aforementioned theories is abundant. As the violent video game debate has had a precursor in the debate on the effects of TV-violence, related evidence on the hypothesized link exists. Longitudinal research on the effects of TV-violence has shown that the amount of viewing TV-violence in childhood predicts young adults' self- and other-reported aggression much more than childhood aggression predicts young adults' TV-violence consumption [Huesmann et al., 2003]. Owing to the activity of the gamer, violent computer games may be more harmful than passive exposure to media [Carnagey and Anderson, 2004]: A hostile virtual reality, higher number of violent scenes in the games, symbolically enacting cruelty instead of perceiving it, reinforcement of atrocities, replacement of aggression-inhibiting tendencies—all of these are matter for concern [Gentile and Anderson, 2003].

Based on meta-analyses of several studies, Anderson and Bushman [2001] inferred a substantial causal effect of computer game violence on aggressive behavior, aggressive cognitions and emotions, cardiovascular arousal, as well as on (reduced) helping behavior [Anderson, 2004; Anderson et al., 2003]. Even if only a small effect existed outside the laboratory, Bayesian logic proves that, due to the high base rate of people consuming large amounts of video game violence, consequences on a societal level would be drastic.

In sum, our understanding of the matter has developed to the point where investigating the mediating mechanisms and exploring the moderating variables becomes more important than establishing any effects themselves. This having said, the same does not apply to a relatively new class of theories and measures. So far, few studies in aggression research have dealt with implicit cognition and even fewer have utilized newly developed implicit measures of aggressive dispositions in media violence research.

Automatic Aggression-Related Cognitions and Impulsive Aggressiveness Dispositions

Beginning with Schneider and Shiffrin [Schneider and Shiffrin, 1977; Shiffrin and Schneider, 1977], the distinction between automatic and controlled processes has become quite common. Huesmann [1988, 1998] applied the distinction between automatic and controlled processing to aggressive behavior [see also Dodge and Crick, 1990]. Also the general aggression model [Anderson and Bushman, 2002] distinguishes thoughtful action from impulsive behavior. The most extensive application of automatic processes to social behavior in general has been laid out in the reflective–impulsive model (RIM) [see Strack and Deutsch, 2004, for an in-depth discussion]. The model summarizes many findings on human automaticity based on implicit measurement procedures. RIM allows for the mutual influence of two cognitive systems in producing human behavior: one associative and one reflective system, but interconnections between both systems exist.

That automatic processes can be held at least partly responsible for the emergence of aggressive behavior is not a new insight [see Todorov and Bargh, 2002, for an overview]. Situational priming of mental constructs in the range of few hundred milliseconds, even below the subliminal threshold, reliably biases people's perceptions of ambiguous behavior, and it can guide the selection of behavioral options [Berkowitz, 2008; Dodge and Crick, 1990; Zelli et al., 1995]. Depending on whether the situation activates the concept of rudeness or the concept of politeness, the likelihood to interrupt a conversation partner changes—without mediation by an intentional stance [Bargh et al., 1996].

What is less obvious from our discussion so far is how each of the reflective and impulsive pathways can be predicted. All the models allow automatic associations as dispositions to behavior. Based on spreading activation in semantic networks, associations efficiently predispose the organism to the spontaneous selection of behavioral scripts. Importantly, behavioral impulses can be at variance with one's personally endorsed standards, or social norms, and this may be the case even without the person being aware of it. Whether deliberate reflection or impulses will determine behavior, depends on the cognitive capacity and motivational resources for self-regulation, which themselves might be impaired due to temporal or chronic influences [Baumeister et al., 2000; DeWall et al., 2007; Fazio and Towles-Schwen, 1999; Muraven and Baumeister, 2000].

With the notion of spreading activation in mind implicit measures have been developed that try to tap into automatic associations in the range of a few hundred milliseconds [Fazio and Olson, 2003]. It was shown that explicit measures, which are based on deliberation and reappraisals, mainly determined behavior under reflective control, whereas implicit measures predominantly predicted impulsive tendencies and behavior in less-controlled situations [Friese et al., 2008; Hofmann and Friese, 2008; Hofmann et al., 2008]. The latter finding does not contradict the idea that clever explicit measurement procedures can likewise uncover automatic influences in a broad sense. Behavior is the product of both types of processes to a sizable extent, and the situation is responsible for moderating their relative impact.

The question is whether the idea of associative networks and priming procedures can be exploited in the domain of aggression, as it has been done in other domains, so that assessing interindividual differences in people's proneness to impulsively aggress becomes feasible. Assuming automatic aggressive dispositions and using implicit measures to detect them is in line with recent calls to integrate neo-associationistic approaches into explanation and prediction of aggression. In doing so, both classic theoretical and newer paradigms are combined [cf. Berkowitz, 2008; Bushman, 1998].

Connecting Implicit Measures, Violent Video Games, and Aggression Research

We suggest that implicit measurement techniques[1] could be a useful addendum to the agenda of aggression research. In contrast to traditional explicit measures such as questionnaires, implicit measures do not rely on conscious self-report, but on the measurement of hard-to-control spontaneous associations. They typically draw on reaction-times in categorization tasks within a few hundreds of milliseconds, that is, within the fraction of a second where also automaticity effects can be observed.

Implicit measures are considered to be less susceptible to distortion by demand characteristics, social desirability, and other biasing factors such as low levels of introspection [Degner et al., 2006]. Crucially, due to the limited time for responding, information processing in implicit measures differs distinctively from responding to a questionnaire so that both types of measures display their merits, particularly when predicting different kinds of behavior: Dissociations between implicit and explicit measures in predicting impulsive and controlled behavior typically result [Asendorpf et al., 2002; Hofmann et al., 2007], and treatments can affect the associative and reflective level independently [Gawronski and Bodenhausen, 2007]. Heavy players of violent video games may claim to be immune to side effects, and at the reflective level this may hold, but at the associative level the picture may look quite different. Owing to the nature of the game, impulsive behavior and automatic associations, aside from intentions, could be reinforced in violent computer games.

Uhlmann and Swanson [2004] observed exactly such a predicted increase of aggressive cognition after 10 min of playing a violent computer game in the lab, when aggressiveness was measured objectively via response latencies in an Implicit Association Test [IAT; Greenwald et al., 1998]. Other research shows that these IATs are predictors of impulsive aggression which cannot be explained by

[1]Throughout the article we stick with the common name "implicit measures" for indirect, latency-based measures. Note that the ideas that the *constructs* proper reside at an implicit level, or that the associations themselves need to be *acquired* implicitly, have been given up, and there is no doubt that most measurement *procedures* cannot be deemed implicit [Blanton et al., 2006; Fiedler et al., 2006; Karpinski, 2004].

self-report and observer ratings [Banse and Fischer, 2002; Gollwitzer et al., 2007].

As the study by Uhlmann and Swanson [2004] is, to our knowledge, the only published research that investigated the influence of violent computer games on cognition as assessed by the IAT, let us describe their main findings. Playing a first-person shooter increased implicit aggressiveness. Despite being convergent with theory, some doubts remain. The lack of a nonplaying control group does not permit a conclusion whether the violent game raised aggressive cognitions or whether the playing control condition caused participants to become more peaceful. Then, Uhlmann and Swanson's games presumably differed with regard to the elicited physiological arousal and involvement. The nonviolent game ("Mahjongg") was a puzzle that differs from the violent game ("Doom"), a first-person shooter, in terms of excitation, task complexity, competition, and frustration. The missing equivalence prohibits inferring a causal link [Anderson et al., 2004]. Arousal confounds need not pose a problem for explicit measures of aggression, yet applying speeded-classification tasks after playing arousing games might have affected sorting performance in the IAT. As a consequence, group differences may reflect blurred measurement, rather than changes in cognition proper.

Study Aims

We had two aims in mind when planning this study: First, a conceptual replication of Uhlmann and Swanson's [2004] study seemed in place, while simultaneously controlling for arousal and task differences of the games. Second, given the small number of studies on the causal impact of violent and prosocial electronic games on implicit measures, we wanted to extend the data basis: We expected that playing a violent game should prime aggressive cognitions, whereas playing a peaceful game should prime peaceful cognitions.

METHOD

Hypotheses

We compared three groups, relative to a control condition, with regard to changes of aggressiveness following violent gaming, nonviolent gaming, or not gaming at all. In the *violent game*, participants acted as first-person shooters and targeted a virtual weapon at hostile soldiers, popping up in a virtual wood, by moving the hairlines of the gun with the mouse and firing at them with mouse clicks. In the *peaceful game* participants watered as many sunflowers popping up in the woods at the same rate and pace as the soldiers in the violent condition. An *abstract game* required the clicking of colored triangles without any meaning attached to these triangles, but with identical timing parameters and reinforcement stakes. This allowed us to examine whether violent content and watering sunflowers distinctively sway associations as compared with a control condition. Finally, nonplaying participants worked on a *reading task* of a nonarousing newspaper report, constituting a baseline for potential arousal differences due to playing vs. not playing.

In line with Uhlmann and Swanson [2004], we predicted that, controlling for pretest differences among participants, the implicit aggressive self-concept should be highest after first-person shooting, followed by abstract gaming, then by sunflower watering. Implicit measures should be particularly informative on alterations of associative structures. Associating oneself with violent acts should give rise to aggressive cognitions, whereas associating oneself with peaceful acts should render peaceful associations active. As we kept the virtual environment, the psychomotor task, and the gaming parameters constant, we also expected that the level of physiological arousal among the three game conditions should converge. This circumstance would demonstrate the equality of the game contexts and render explanations of post-treatments effects in terms of plain arousal differences improbable.

Sample

A sample of 96 students at Heidelberg University of various majors took part in a study on the influence of computer games on (unspecified) cognitive performance parameters in exchange for course credit or a chocolate bar. After controlling for high error rates [20% of errors at most in the critical IAT and Single-Target IAT (ST-IAT) blocks; see Greenwald et al., 1998], 89 participants (68.5% females) remained in the sample.[2] Mean age amounted to 24.64 yrs (SD = 5.35). Most participants were skilled in computer usage and gaming: Many reported owning a Personal Computer ($N = 86$), Sony Playstation (9), Microsoft Xbox (2), or a Nintendo Gameboy (9). Daily computer usage was 2.53 (SD = 2.65) hr on average, and the average weekly consumption of video games

[2]Owing to technical problems, the recording of one participant's physiological data failed.

summed up to 5.16 (SD = 7.90) hr. Participants were randomly assigned to one of the four conditions under the constraint of keeping gender proportions across the conditions equal. This resulted in 6–8 males and 14–16 females in each condition.

Independent Variable

Although the control group encountered a reading task, that is, an article from the German magazine "DER SPIEGEL" which was judged as emotionally neutral, the experimental groups encountered one of three computer games. Irrespective of the specific treatment condition, the virtual environment (a forest scene) and the actions (a left-side mouse click of the right hand) were identical (Fig. 1). In the violent game, participants were exposed to a war scenario that required shooting enemy soldiers from a first-person perspective in order to score high. Soldiers returned fire if they were not eliminated immediately. The goal was to shoot as many enemies as quickly as possible by firing at them with mouse clicks (hits), before they fired back and disappeared, resulting in score losses (misses). The mean rate of soldiers per minute could be determined by the programmer and was kept constant across participants (and conditions), but the program implemented a random component with regard to timing and location of the targets so that players could not routinely counter the attacks. Misses after the fraction of a second resulted in being injured and decreased the score, signaled by a different sound than for hits, which were visually emphasized by blood spills.

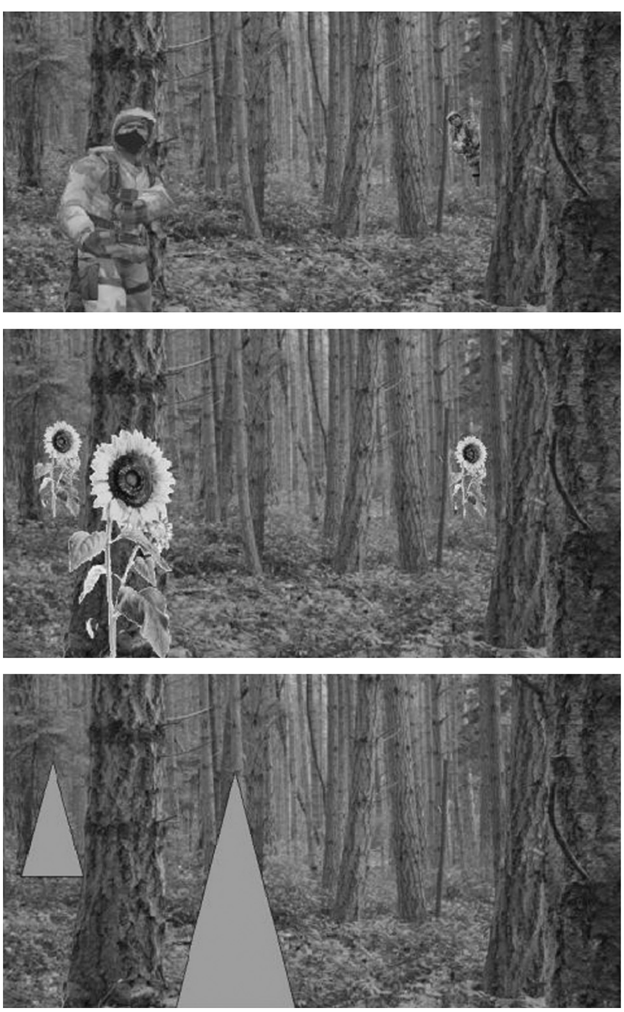

Fig. 1. Screenshots of the violent, peaceful, and abstract game (printed in greyscale).

By contrast, in the peaceful game sunflowers popped up in the same wood in the same speed like the soldiers in the violent game, yet the players' task was to water the flowers with their watering can, else they "died" visually due to water shortage. Whenever this happened, a "sad" sound occurred and reminded a participant to water the sunflowers continuously and fast. On success, a player's score increased, as indicated by a sound of accomplishment. Misses resulted in the same loss of points as in the violent game. Finally, in the abstract game participants removed the colored triangles that popped up in the woods by pinpointing them with a small cursor triangle before clicking the mouse button. Acoustic and visual signals added relevance to hits and misses.

Dependent Variables

Big five. A German 40-item version of the International Personality Item Pool [IPIP40; Goldberg, 2001; Hartig et al., 2003] provided a basic description of personality in terms of the five-factor model: extraversion, neuroticism, conscientiousness, openness, and agreeableness [John and Srivastava, 1999]. Both the five-factor structure of the IPIP40 as well as its construct validity have been demonstrated beforehand [Buchanan et al., 2005]. We used the IPIP40 in order to control for pretest differences among the sub-samples. Internal consistencies of the scales were adequate, Cronbach's $\alpha = .74$–$.90$.

Aggression questionnaire. We administered Buss and Perry's [1992] 29-item aggression questionnaire [BPAQ; German version by Amelang and Bartussek, 2001] to control for pre-existing group differences and to investigate postexperimental changes of aggressiveness. The German version fits the well-validated four-factorial structure: physical aggression, verbal aggression, anger, and hostility [Herzberg, 2003; von Collani and Werner, 2005]. Reliability of the sub-scales, $\alpha = .62$–$.78$ ($.67$–$.85$), and the total scale, $\alpha = .85$ (.87), proved adequate (post-test values in brackets).

Implicit Association Tests. The computer-based IAT and its derivate, the ST-IAT [Karpinski and Steinman, 2006; Wigboldus et al., 2004; unpublished], were administered as implicit measures of cognitive antecedents of impulsive aggression, known as the aggressive self-concept [Banse and Fischer, 2002]. In the IAT, the main dependent variable, response latencies, resulted from two sorting tasks that cross the two focal attribute concepts—*aggressive* and *peaceful*—with the two target categories, *self* and *other*. After 20 practice trials for attributes and targets each, 40 stimuli of both targets and attributes had to be categorized (see Table I; Block 4–7): In one block *self+peaceful* (and *other+aggressive*) were mapped to identical response keys, in the other block the category–response-key assignment reversed, *self+aggressive* (and *other+peaceful*). Stimuli were randomly drawn from one of the four categories. Both blocks were administered in counterbalanced order across the sample to control for block order effects. The difference between the mean response latencies of the two critical blocks (i.e., IAT effect), served as an index of the association of the self to the aggressive vs. peaceful pole of the dimension. Typically faster responses for the *self+peaceful* than for the *self+aggressive* block result. Hence, when taking individual block differences of zero milliseconds as a reference point, *positive IAT scores indicate a peaceful self-concept* and *negative IAT scores indicate an aggressive self-concept*. Previous studies showed that IATs predicted the amount of violent game playing [Uhlmann and Swanson, 2004], accounted for unique variance in the aggression of ice hockey players as indicated by penalty time-outs [Banse and Fischer, 2002], and detected the impact of a social competence intervention [Gollwitzer et al., 2007].

Because of the criticism pertaining to the relative nature of the IAT [Blanton et al., 2006; Fiedler et al., 2006; Karpinski, 2004], we additionally applied an aggressiveness-ST-IAT that omitted the contrast category *other*, as it is unclear what exactly test-takers associate to an unspecified IAT category, such as *other*. The measurement of latencies, the block structure, and the stimuli of the two critical blocks remained the same as in the IAT, yielding one compatible block with *self+peaceful* on the one key and *aggressive* separately on the other key, and one incompatible block with *self+aggressive* (*peaceful* separate). The simpler task structure usually decreases latencies, but, crucial for the calculation of block difference scores, across both blocks there is always one uncoupled category. For nonrelative target objects, such as the self-concept, an ST-IAT may contain less nuisance variance than an IAT. In our own pilot study, a self-concept ST-IAT reflected past violent video game exposure better than an attitude-toward-aggression-IAT, probably as a result of range restriction of the true-score variance of participants' evaluative associations in the latter measure [Bluemke and Zumbach, 2007]. Successful ST-IAT applications have shown that the ST-IAT can do almost as good in psychometric terms as the IAT. Nevertheless, research on this tool is still warranted as the evidence for the usefulness of an aggressiveness-ST-IAT is scarce. We reduced the influence of the asymmetric nature of the task by drawing 10 self-related stimuli, 11 stimuli of the coupled category, and 14 stimuli of the unpaired category, resulting in 35 stimuli per critical block and an almost equal number of left-hand and right-hand responses [40 vs. 60%; see Table I, Block 1–3; cf. Bluemke and Friese, 2008; Friese et al., 2007].[3]

The ST-IAT always preceded the IAT so as not to prime the category *other* before taking the ST-IAT. Irrespective of whether participants encountered the compatible or the incompatible block first, they received the same order of blocks for the post-test. Latencies were treated according to the D_5-algorithm regarding the treatment of missing data and error penalties [Greenwald et al., 2003], resulting in metrics equivalent to z-standardized scores or d-scores. Thus, ST-IAT and IAT effects are expressed in units of an individual's standard deviation pooled across both (task-specific) critical blocks. Individual differences were assessed with boundary reliability, $\alpha = .68$ (.64) and .64 (.73). Again, to summarize, *positive IAT or ST-IAT scores indicate a peaceful self-concept* and *negative IAT or ST-IAT scores indicate an aggressive self-concept*.

Physiological arousal parameters. As we wanted to preclude any arousal differences between groups, we assessed heart rate (HR) and skin conductance (SC) as parameters of emotion-related physiological arousal by using the Biopac student lab PRO 3.6.7. [e.g., Carnagey et al., 2007; Clements and Turpin, 1995; Malmstrom et al., 1965]. The measurement procedure was divided into six sections. Data were continuously gathered, and aggregates of 30-second intervals were analyzed for each of the following phases: a baseline immediately after

[3]The disproportionate number of categories in the ST-IAT prevents that both the number of left and right key-strokes and the number of peaceful and aggressive stimuli in the two critical blocks can be balanced. We chose a solution between both extremes.

TABLE I. Structure of ST-IAT and IAT Including (ST-)IAT Items (Translated From German)

Sequence	Block 1	Block 2	Block 3	Block 4	Block 5	Block 6	Block 7
Task	Attribute discrimination	Initial combined task (here: compatible)	Reversed combined task (here: incompatible)	Target-concept discrimination	Initial combined task (here: compatible)	Reversed target discrimination	Reversed combined task (here: incompatible)
Task instructions	Aggressive Peaceful	Aggressive Peaceful+Self	Aggressive+Self Peaceful	Others Self	Aggressive+Others Peaceful+Self	Others Self	Aggressive+Self Peaceful+Others
Stimuli	Compromise Fight Agree Blow Reconciliation Give in Hurt Revenge Hit Make peace	Me Fight Agree Mine Blow Self Reconciliation Give in Hurt I Revenge Hit Make peace My Compromise ...	Me Fight Agree Mine Blow Self Reconciliation Give in Hurt I Revenge Hit Make peace My Compromise ...	Me You Mine Yours I Self They Their Them My	Me Fight Agree Mine Blow Self Reconciliation Give in Hurt I Revenge Hit Make peace My Compromise ...	Me You Mine Yours I Self They Their Them My	Me Fight Agree Mine Blow Self Reconciliation Give in Hurt I Revenge Hit Make peace My Compromise ...
Number of trials	10 aggressive 10 peaceful	14 aggressive 11 peaceful 10 self-related	11 aggressive 14 peaceful 10 self-related	10 self-related 10 other-related	10 aggressive 10 peaceful 10 self-related 10 other-related	10 self-related 10 other-related 10 self-related 10 other-related	10 aggressive 10 peaceful

Note: Within the task instructions, spatial position of the categories indicates the left or right response key. Target and attribute stimuli alternated in critical IAT blocks (here: depiction of an arbitrary sequence of stimuli).

attaching the electrode (Pre-1), a pre-treatment baseline (Pre-2), a treatment phase subdivided into one early, one mid-term, and one final interval (T1–T3), and a post-treatment phase before the detachment of the electrode (Post).

Procedure

After entry in the lab, we obtained written informed consent that participants might randomly end up in a violent game condition and stressed that they could opt out at any point in time without giving any reasons. None of the participants used this option, neither in response to the initial information, nor during the course of the experiment. At first, participants reported on socio-demographic variables, and then took a personality questionnaire related to the five-factor model, before they encountered baseline measures of an aggression-specific questionnaire, an ST-IAT, and finally an IAT. Next, the experimenter attached the devices for measuring HR and SC at the index finger of the left hand. Following a short introduction to the randomly chosen game condition, participants played, or read, for a period of only 5 min. Arousal measurement continued until a re-test of the aggressiveness questionnaire was completed, but the devices were detached before we administered the implicit measures a second time. Subsequent to questions on computer usage [derived from Krahé and Möller, 2004], the session ended by careful debriefing of participants. In sum, all phases lasted about 30 min altogether.

RESULTS

Explicit measures

To preclude any pre-existing group differences, we examined the Big Five personality scores before treatment. According to a multivariate analysis of variance on the IPIP40 scales, participants were comparable $F(15, 249) < 1$, $\eta^2 = .04$, regardless of the specific Big Five scale, $F\text{s} \leq 1.26$, $P\text{s} \geq .30$, $\eta^2\text{s} \leq .04$. We also checked whether the random assignment to experimental conditions worked by analyzing trait aggressiveness. As expected, neither before, $F < 1$ ($\eta^2 = .03$), nor after the treatment, $F(3, 85) = 1.36$, $P = .26$, $\eta^2 = .05$, did substantial group differences in self-reported aggressiveness on the BPAQ total scale exist. Replicating Uhlmann and Swanson's [2004] findings, trait questionnaires did not respond to video play, according to an analysis of the difference scores of BPAQ total, $F(3, 85) = 1.02$, $P = .39$, $\eta^2 = .04$. Scores of BPAQ subscales likewise did not change (all F-values ≤ 1.21).

Arousal

All groups displayed a typical pattern of initial excitement and habituation (Fig. 2). As expected, when testing the equivalence of games in terms of physiological arousal, according to a 4 (experimental condition) × 6 (time: Pre-1, Pre-2, T1, T2, T3, and Post) analysis of variance (ANOVA) with repeated measurement on the latter factor, no group differences on HR emerged, $F < 1$ ($\eta^2 \leq .01$). Importantly, there was no interaction between time trends and experimental treatment, $F < 1$ ($\eta^2 \leq .03$). Running the same analyses on SC as a more sensitive measure of arousal also showed no reliable differences between groups, $F < 1$ ($\eta^2 \leq .03$), and time trends were not moderated by experimental condition, $F\text{s} < 1$ ($\eta^2 \leq .02$).

As could be expected, the violent game showed a slight numerical increase in SC (from Pre-2 to T1). We therefore examined each of the six measurement occasions separately. Only at the beginning of the play (T1) did significant variation exist, $F(3, 84) = 5.04$, $P = .003$, $\eta^2 = .15$. Post hoc tests according to Tukey (HSD) revealed that the violent game resulted in somewhat higher excitement compared with the abstract game and the reading task ($P\text{s} \leq .01$). Importantly, violent and peaceful games did not differ significantly, $P = .14$. Only 1 min later, the initial startle-like reaction had vanished ($F < 1$ at T2).

Implicit Measures

The impact of games was analyzed by a one-factorial ANOVA on change scores between IAT pre- and post-test (Table II). Replicating the findings by Uhlmann and Swanson [2004], type of game significantly influenced implicit aggressiveness, $F(3, 85) = 2.93$, $P = .04$, $\eta^2 = .09$.[4] Introducing participant sex as a control factor resulted in an interaction between sex and game content, $F(3, 81) = 3.33$, $P = .02$, $\eta^2 = .11$. Whereas change scores did not differ as a function of sex, $F < 1$, the impact of game content became clearer at the same time, $F(3, 81) = 4.00$, $P = .01$, $\eta^2 = .13$. The pattern of IAT change scores and the significance of the contrasts between games within sex indicated that the sex by game interaction was particularly driven

[4]Introducing Order of Block Compatibility did not change conclusions on the game factor, $F(3, 81) = 2.92$, $P = .04$, $\eta^2 = .10$, other $F\text{s} < 1$. Also using BPAQ pretreatment scores as covariates in ANCOVA models did not alter the conclusions, though some of the covariates tended to explain small portions of IAT variability, $P\text{s} \geq .08$, $\eta^2\text{s} \leq .04$.

by the peaceful game producing less aggressive self-concept among males, and by the violent game producing more aggressive self-concept among females (cf. Table II).

As regards the ST-IAT change scores, overall no significant treatment differences resulted, $F(3, 81) = 1.58$, $P = .20$, $\eta^2 = .05$. If anything, inspection of the means suggested a descriptive trend in the nonhypothesized direction. Consequently, we refrain from comparing post-treatment scores by powerful contrast analyses. The only other significant factor was an order-of-block effect, $F(3, 81) = 28.26$, $P = 10^{-6}$, $\eta^2 = .26$. Obviously, the pretest ST-IAT effect suffered from a substantial order-of-block effect, $F(3, 81) = 18.41$, $P = .0001$, $\eta^2 = .19$. No such cause affected the measurement in the post-test ($F < 1$), so that the order effect carried through to the pre-/post-test difference scores. Testing the idea that the first ST-IAT did not reflect true-score variance, but only at the second sight, we analyzed post-test scores on their own; however, variance could not be attributed to any factor, neither to experimental group, nor order of blocks, nor an interaction (Fs < 1). Whereas the IAT came up with results as expected, the ST-IAT turned out to be deficient.

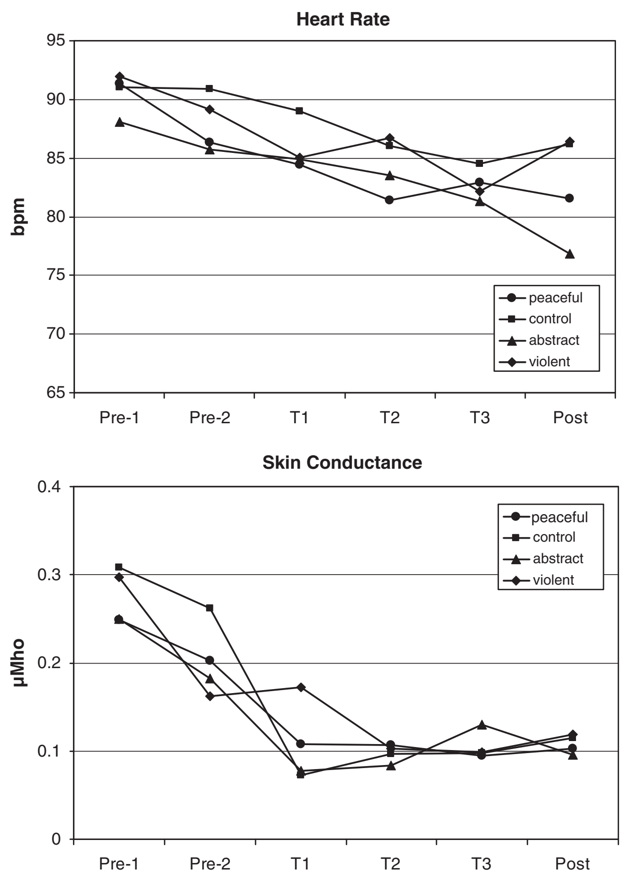

Fig. 2. Physiological arousal according to heart rate and skin conductance.

Correlations

As counterbalancing of block order in both implicit measures introduces error variance, our chances for detecting relationships were reduced. Nevertheless, across all participants, the pretest aggressiveness-IAT correlated marginally with BPAQ trait-aggressiveness, $r = .18$ ($P = .09$). Convergence is particularly evident with regard to physical aggression, $r = .22$ ($P = .04$), and anger, $r = .24$ ($P = .02$), but not with regard to verbal aggression, $r = .06$ ($P = .55$), and hostility, $r = -.001$ ($P = .99$). Once participants had encountered the games, the post-test IATs did not correlate positively any longer with BPAQ scores. Interestingly, the IAT was specifically related to aggressiveness, yet not to broader personality traits, rs $\leq .14$ (Ps $\geq .19$), whereas the ST-IAT did not correlate significantly with either type of measure. Participants' post-test scores on the implicit aggressiveness

TABLE II. Effect of Computer Games on Implicit Measures of Aggressiveness (Estimated Marginal Means)

				Pretest		Post-test		Pre/Postchange scores					
				Overall ($N = 89$)		Overall ($N = 89$)		Overall ($N = 89$)		Males ($N = 28$)		Females ($N = 61$)	
	N	N_{male}	N_{female}	M	SE	M	SE	M	SE	M	SE	M	SE
IAT effect													
Peaceful	21	6	15	0.51	0.095	0.58	0.095	0.07^{a}	0.102	0.43^{a}	0.184	-0.08^{a}	0.116
Control	22	8	14	0.59	0.088	0.54	0.093	$-0.04^{a,c}$	0.100	-0.27^{b}	0.159	0.09^{a}	0.120
Abstract	23	7	16	0.65	0.086	0.48	0.091	$-0.18^{b,c}$	0.098	-0.33^{b}	0.170	$-0.11^{a,c}$	0.113
Violent	23	7	16	0.64	0.086	0.31	0.091	-0.33^{b}	0.098	-0.28^{b}	0.170	$-0.35^{b,c}$	0.113

Positive IAT scores reflect a peaceful automatic self-concept, whereas negative scores represent a more aggressive self-concept. Thus, negative change scores represent a change toward a more aggressive self-concept.
[a,b,c]Mean change scores not sharing a superscript within a column are significantly different at $P < 05$.

measures partly reflected the pretest rank-order despite treatment, though test–retest correlations for IAT and ST-IAT were quite small, $rs = .38$ and $.25$ ($Ps \leq .02$), respectively. By contrast, the test–retest correlations of explicit aggressiveness for the BPAQ sub-scales amounted to $rs = .89–.93$ ($Ps < .001$). As evident in unlike rank-order consistency, and aside from mean level changes, the IAT was clearly affected by the treatment, whereas the questionnaires were not.

DISCUSSION

Summary of Findings

This study examined the causal effects of computer games on implicit measures of aggressiveness. Computer games were carefully matched in terms of target location, how quickly the targets appeared, and the physical mouse actions taken toward these targets. Except for the specific content and symbolic actions carried out by the players, the games used in the study paralleled each other and did not produce different levels of arousal. The results revealed that for all participants playing violent games increased implicitly measured aggressive self-concept significantly more than playing a peaceful game. For males playing a peaceful game also reduced aggressive self-concept more than playing an abstract game, or simply reading. For females playing a violent game also increased aggressive self-concept more than playing an abstract game, or simply reading. These results substantiate and extend earlier findings by Uhlmann and Swanson [2004]: Even brief playing of violent computer games causes increases in aggressive cognitive structures. On the other hand, playing peaceful games reduces aggressive cognitive structures. Whether the gender differences we found with regard to the impact of violent and peaceful content are conclusive will depend on the outcome of future studies that employ an equal and sufficient number of participants for the reliable estimation of cell means. Although the short-term design renders such influence only transient, it demonstrates causality with sufficient internal validity. Neither excitation transfer nor interference when executing the psychomotor responses in the reaction-time task can be held responsible for group differences. All the groups showed comparable habituation in the course of playing. One might have expected lower excitement in the reading task, but we can only speculate that the newsmagazine article was not as unexciting as expected, or a constant environment in the games allowed quick habituation. Yet, the important message here is that arousal differences cannot account for the differences in aggression-related associations, or the measurement thereof.

Implications of Findings

First of all, implicit measures, which play an increasingly prominent role in other psychological domains, can be used to tap into spontaneous associations related to aggression. Whether explicit questionnaires are essentially sensitive to short-lived laboratory effects is only one question [Farrar and Kremar, 2006]. Studies that exclusively rely on self-report questionnaires (e.g., after blatant violence exposure) could be trapped by participants' incapability or unwillingness to introspect as well as by socially desirable responding and underreporting [Becker, 2007; Gregoski et al., 2005]. Implicit measures that additionally qualify for the prediction of less-controlled forms of aggressive behavior or aggression in situations less-reflected upon, should complement researchers' collections of measures in the future. Incorporating implicit measures is important for another reason. As regards the relation of explicit and implicit measures in predicting aggressiveness, there is converging evidence that they are only weakly—though meaningfully—related, despite the fact that a causal influence of violent computer games on both kinds of measures has been shown. Using more specific measures of aggressive feelings, hostility, and aggressive cognitions may illuminate the relative contributions of reflective and impulsive determinants on aggressive behavior.

Second, despite substantial effect sizes resulting from a brief intervention, variance among participants' post-treatment scores apparently was high. We discovered treatment effects reliably only when difference scores controlled for interindividual differences at pretest. The fact that Uhlmann and Swanson [2004] found significant differences between violent and nonviolent players without a baseline measure may have resulted from a potential arousal confound. Future best-practice research will profit from combining the experimental approach with the interindividual perspective to explain variance in the data.

Third, not all the processes in implicit measures are well understood. This is evident with the aggressiveness-ST-IAT that failed to reproduce IAT-based findings. Why would the *other*-category, which has been identified as a source of nuisance variance in previous IAT research, facilitate the measurement of aggression-related cognitions compared with a ST-IAT without a counter-category? We discuss two reasons, a methodological and a theoretical one. Foremost, though order-of-block effects in the IAT can be reduced by using more practice trials [Nosek et al., 2005], the same has not been shown for the ST-IAT so far. The fact that only the pretest ST-IAT showed order effects suggests that increasing the number of practice trials may overcome this pitfall.[5] Equally important, but more of a theoretical argument, aggressiveness-ST-IATs lack the social comparison processes that might be required to tap into aggression-related associations which are essentially interpersonal. Let us compare the aggressiveness-ST-IAT to a more successful domain of single-category applications: When assessing self-esteem [Gregg and Sedikides, 2007; submitted; Karpinski and Steinman, 2006] social comparison *can* play a role (e.g., attractiveness or competence relative to others), yet self-esteem resources stem from nonsocial behavior and noncompetitive tasks, too. The same cannot be said for *interpersonal* aggressive behavior. ST-IATs might better capture *personal* or *self-directed* aggressive dispositions, particularly in the presence of a salient context as, for instance, when using stimuli pertaining to *auto*-aggressive behavior (e.g., self-mutilation, suicide, cutting). If this is correct, we should not assume that the ST-IAT is equally prone to reflect violence exposure as the IAT. There is now other evidence that IATs predict alcohol-related behavior better than ST-IATs do [Houben and Wiers, 2008]. Currently we cannot recommend an interpersonally oriented aggressiveness-ST-IAT as a substitute for an aggressiveness-IAT, unless further research clarifies the role of the *other*-category.

Finally, our findings attest to the importance of games that promote prosocial attitudes and prosocial behavior. Media research has strongly focused on the detrimental impact of games and promoted the violent-content hypothesis. Turning to the other side of the coin, a peaceful-content hypothesis is in place, too. Offering alternative games additionally or as a substitute to young and old players could reduce risk factors. Vulnerability to violent video games could be abridged by restoring the balance between violent and nonviolent input of particularly of those players that seem highest at risk.

Directions for Future Research

To outline the route that future studies could take in aggression research generally and in media research in particular, we note an obvious limitation of our study, namely the short-termed experimental effect. Despite previous evidence for a long-term relationship between exposure to violent video games in cross-sectional studies [Uhlmann and Swanson, 2004], the longevity of the changes of automatic associations should be evidenced in longitudinal studies.

What is also lacking is the demonstration that changes in the automatic self-concept, subsequent to violent (or peaceful) game play, can predict inter-individual differences in behavior. Though a significant relationship between IAT and aggressive behavior has been demonstrated in sports [Banse and Fischer, 2002], it is important to show the mediational path from media violence exposure via implicit measures of aggressive dispositions to aggression. Following the dissociation of both kinds of measures [Strack and Deutsch, 2004], implicit measures can be expected to outperform explicit measures in predicting impulsive aggression or aggression in situations of low control. Impulsive and reflective processes are likely to interact in producing aggressive behavior, and most experimental tasks for measuring aggressive behavior are not process-pure. But the more people lack the cognitive resources for self-regulating their behavior (e.g., due to ego-depletion), the more should impulses determine who is to show aggressive behavior, and the better should implicit measures predict it [Hofmann et al., 2008].

Also, research related to trait impulsiveness suggests itself for adopting implicit measures. Traditional models of impulsive aggression have postulated at least two distinguishable factors, functional vs. dysfunctional impulsivity [Barratt, 1991; Dickman, 1990]. Whereas functional impulsivity increases the likelihood of appropriate quick decisions in social situations, dysfunctional impulsivity results in speedy, nonreflective decisions that are inappropriate from a normative point of view. Interestingly, both forms do not relate to trait aggressiveness [Vigil-Colet and Codorniu-Raga, 2004] and the small correlation between IAT and BPAQ parallels this finding. This raises the question whether implicit aggression and impulsivity relate to each other [Enticott et al., 2006; White et al., 1994].

[5] As a cautious note, data of our own lab show that the simpler task structure renders the ST-IAT more likely to suffer from speed gains simply due to learning curves. Sequential block effects, irrespective of the block compatibility and amount of training, may result, even when as many as 350 trials pose ample opportunity for practice [Bluemke and Friese, 2008].

Finally, this study demonstrated the importance of using well-controlled media contents and a multimethod approach that embraces implicit measures to determine the genuine impact of media exposure. With more and more sophisticated and realistic games, an increasing market, and hardly controllable access to violent games, increasingly precise research on media influence is necessary. Adequate interventions can only be justified on the basis of fine-grained evidence on the violence exposure–aggression link. Future studies applying implicit measures will help to predict impulsive aggression as well as long-term effects of regular playing, or differential effects of simply watching vs. virtually enacting violence.

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