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Comparing Apples and Oranges? Evidence for Pace of Action as a Confound in Research on Digital Games and Aggression

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Most studies investigating the effects of violence in digital games on aggression and physiological arousal feature two groups of participants either playing a violent or a nonviolent game. However, violent content is usually not the only dimension on which the games used in these studies differ. This raises the issue of possibly confounding variables. We conducted a study in which the displayed violence and the pace of action of a first-person shooter game were manipulated systematically through game modifications (modding), whereas other variables were controlled for. Dependent variables were physiological arousal (autonomic and behavioral) during play, and postgame aggressive behavior. Aggressive behavior was not influenced by either of the two variables. Although both violence and pace of action did not affect autonomic arousal, there was an interaction effect of these variables on behavioral measures of arousal. Playing a fast-paced game inhibited participants' body movement, particularly when the game was nonviolent. A higher pace of action and displays of violence also caused players to exert greater pressure on the input devices. The findings of our study support the assumption that research on the effects of digital games should consider more variables than just violent content. In sum, our results underline the importance of controlling potentially confounding variables in research on the effects of digital games.

Keywords: digital games, violence, arousal, pace of action, stimulus selection

More than 25 years after the publication of one of the earliest experimental studies into the effects of violent digital games on aggression and physiological arousal by Winkel, Novak, and Hopson (1987), the question whether virtual violence affects real-life behavior is still far from being answered. Despite—or maybe because of—the mixed scientific evidence, the public and academic debate about this issue is still ongoing and heated (Grimes, Anderson, & Bergen, 2008).

The challenges associated with the appropriate selection of stimulus material are one possible reason for the inconclusiveness of previous work (Ravaja & Kivikangas, 2009). The attribution of behavioral outcomes or affect changes to a specific feature of a game, such as violence, is only possible if the variable of interest is manipulated while potentially confounding ones are controlled for. However, a rigorous control of such variables is rarely found in research on digital games, as the ma-

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nipulation of complex stimuli requires a certain degree of technical expertise and familiarity with the stimulus material at hand (Williams, 2005).

One difference between games that may be relevant to behavioral and psychophysiological measures, alongside violent content, is their pace of action. First-person shooter (FPS) games, a genre that is often used in effect studies on digital game violence, are typically fast-paced and require precise reactions and hand–eye coordination from their players. Adachi and Willoughby (2011a) expect *pace of action* to be one of the four main factors in game design—besides *violence, competitiveness*, and *difficulty*—that have an effect on physiological arousal during and aggressiveness after game play, and suggest controlling for it in experimental designs (see Adachi & Willoughby, 2011b). There are also other possibly relevant variables, such as controller characteristics (McGloin, Farrar, & Krcmar, 2013), game outcome (Shafer, 2012), justification of violent in-game actions (Hartmann, Toz, & Brandon, 2010), or perspective (Farrar, Krcmar, & Nowak, 2006). It should be noted that there is also a large variability within individual game genres (e.g., fantasy violence vs. contemporary warfare). Tamborini, Weber, Bowman, Eden, and Skalski (2013) identified three facets–graphicness, realism, and justification–that should be differentiated between when talking about violence in violent games.

In the present study, we manipulated the pace of action and the display of violence of a FPS while holding other game mechanisms constant to be able to assess their relative effects on physiological arousal and postgame aggressive behavior.

Violent Games as Stimuli in Research on Aggression and Arousal

Many surveys, experiments, and longitudinal studies have investigated the effects of violence in digital games. Despite the large body of existing research, the overall findings on the relationship between violent content in digital games and aggression can best be described as ambiguous. There are several studies pointing to a causal relation between violent content and postgame aggression (Anderson & Carnagey, 2009; Hasan, Bègue, & Bushman, 2012), whereas others did not obtain such results (Adachi & Willoughby, 2011b; Ferguson & Rueda, 2010). Findings on physiological responses, such as heart rate (HR), skin conductance level (SCL), or blood pressure are equally inconclusive: Some studies found significant increases during and after playing (Barlett, Harris, & Bruey, 2008), whereas others found no such effects (Anderson & Carnagey, 2009). Even the few longitudinal studies show a similar pattern, with some finding evidence for a long-term effect of repeated exposure to violent games (Anderson et al., 2008), whereas others do not (von Salisch, Vogelgesang, Kristen, & Oppl, 2011). Recent contributions underline the importance of other game characteristics to explain longitudinal effects of digital game use, such as competitiveness (Adachi & Willoughby, 2013). Although there are meta-analyses showing small- to medium-sized effects of violence in digital games on arousal and aggression, and concluding severe real-life implications (Anderson et al., 2010), others found considerably weaker links (Ferguson & Kilburn, 2009; Sherry, 2001, 2007), or expressed concerns about methodological issues and a confounding publication bias (Ferguson & Kilburn, 2010). A recent review of the literature by Ferguson (2013) suggests that the empirical evidence for effects observable outside of psychological laboratories is inconclusive.

The governments of Sweden (Statens Medieråd, 2011) and Australia (Australian Government Attorney-General’s Department, 2010), and the U.S. Supreme Court (Brown v. Entertainment Merchants Assn., 2011) assessed in independent reviews that there is currently no compelling evidence supporting the notion that violent games facilitate problem behaviors in minors. All three reports lament serious methodological issues limiting the significance of media violence effects research. For a detailed examination of the Supreme Court’s Brown v. EMA case, and possible lessons for the scientific community it conveys, see the two opposing perspectives by Ferguson (2013) and Wuller (2013). Regarding the measurement of aggression, there is an ongoing controversy among scholars regarding the operationalization, assessment, and validity of measures of aggressive behavior used in laboratory studies (Ferguson & Rueda, 2009; Ferguson, 2011; Giancola

& Zeichner, 1995; Ritter & Eslea, 2005; Tedeschi & Quigley, 1996, 2000).

Many of the experimental studies on violent games share a basic design: Physiological measures are taken while participants either play a digital game with violent content or another one that is considered nonviolent. Afterward, aggressive behavior is measured via a behavioral test such as the modified Competitive Reaction Time Task (CRTT; e.g., Anderson & Dill, 2000) or the Hot Sauce Paradigm (Lieberman, Solomon, Greenberg, & McGregor, 1999). Determining which games are suitable as stimulus material in such studies, however, is a nontrivial task. As there is no commonly accepted definition of violence in games, scholars tend to select their material based on subjective evaluations or age recommendations, which results in highly diverse assignments of games to experimental conditions. Some authors, for example, consider *Super Mario* games as violent (Anderson & Dill, 2000), while others strongly disagree with this assertion (Griffiths, 1999).

Even more challenging is the selection of stimuli for the control groups, that is, the non-violent games. To be able to attribute the effects observed in behavioral tests of aggression to specific characteristics of the stimulus (such as violent content), it is vital to manipulate the variable of interest, while controlling all other possibly confounding variables so that they do not interfere with the manipulation. Without this control, one can never be certain of which variable(s) actually cause(s) the effects that are measured. In research on violent video games, participants are typically assigned to play a violent or another nonviolent game. However, violence is rarely the *only* dimension on which digital games differ. Examples that illustrate this problem are studies in which groups of participants either played *Grand Theft Auto: Vice City*[1] or *Tetris Worlds*[2] (Cicchirillo & Chory-Assad, 2005), *Mortal Kombat: Deception*[3] or *Dance Dance Revolution Max 2*[4] (Williams, 2009), and *Call of Duty 4*[5] or *Dirt 2*[6] (Hasan et al., 2012).

A simple look at a game trailer, or even at the cover of these games show that violence is hardly the only difference between them. It is possible that other game characteristics than violence influenced the effects observed in those studies. Carnagey and Anderson (2004) suggest doing more pilot testing or manipulation checks on such aggression-relevant dimensions. Until now, however, there is only little research available into the possible effects of game characteristics other than violence on aggression. Adachi and Willoughby (2011a) reviewed the literature for competitiveness, difficulty, and pace of action as potential alternative causes for aggressive responses, and found that in at least 18 experimental studies these variables have not been properly controlled for.

Some researchers have addressed the problem of stimulus control by comparing the games they used on certain dimensions such as excitement, frustration, or pleasantness using self-report items (Anderson & Dill, 2000). There may, however, be other relevant aspects in which games differ, and even for those dimensions that are identified, a postexperimental manipulation check cannot replace control over the differences themselves. This kind of control can be best achieved by using or creating game modifications (mods; Ravaja & Kivikangas, 2009).

Hypotheses and Research Questions

The present study was carried out to assess the effects of game speed and displayed violence on common measures of physiological arousal and aggressive behavior. Against the background of the mixed findings in the existing literature, this study was meant to be explorative with regard to the effects of in-game violence and pace of action on aggressive behavior and arousal. Hence, we formulated our hypotheses and research questions rather carefully where evidence from previous studies was unavailable or ambiguous. Regarding the effects of violence in digital games on aggression and arousal, there is only little evidence of the effects under a more rigorous control of the

[1] Rockstar North. (2002). *Grand Theft Auto: Vice City*. New York, NY: Rockstar Games.
[2] Blue Planet Software. (2001). *Tetris Worlds*. Agoura Hills, CA: THQ.
[3] Midway. (2004). *Mortal Kombat: Deception*. Chicago, IL: Midway.
[4] Konami. (2003). *Dance Dance Revolution Max 2*. Tokyo, Japan: Konami.
[5] Infinity Ward. (2007). *Call of Duty 4*. Santa Monica, CA: Activision.
[6] Codemasters. (2009). *Dirt 2*. Southam, United Kingdom: Codemasters.

stimulus material. We therefore formulated two nondirective hypotheses.

H1: Displayed violence in a digital game has an effect on postgame aggressive behavior.

H2: Displayed violence in a digital game has an effect on autonomic arousal levels during play.

FPSs are highly demanding in terms of attention, reaction speed, and hand– eye coordination. Running is typically the default movement in these games, and the movement speed of the avatars usually exceeds normal human movement speed by far (Løvlie, 2008). According to Adachi and Willoughby (2011a), pace of action is one of four important variables for outcome measures in laboratories when studying effects of digital games, although they do not specify in what way pace of action might interact with effects of other variables (e.g., violent content). To test the potential relevance of pace of action empirically, we wanted to explore the effect of game speed in an FPS game on common measures of autonomic physiological arousal, such as SCL and HR.

H3: Pace of action in a digital game has an effect on autonomic arousal levels during play.

Although Adachi and Willoughby (2011a) do not expect pace of action to have an impact on player aggressiveness directly, they still suspect it to be an important variable to control for, as it might be a source of physiological arousal during game playing. Previous research provided compelling evidence for a link between arousal and negative emotions, particularly aggression (Zillmann, 1983). However, the relationship seems to be more complex, as there are studies showing that arousal increases in individuals being frustrated by another person, and decreases when given the opportunity to retaliate through aggressive means (Hokanson, 1961). There are also observations of aggression not accompanied by changes in hostility or other negative emotions ("affectless aggression," Anderson & Morrow, 1995). Given the mixed evidence and the complex interplay between these variables, we were interested in whether particularly exciting games with an increased pace of action might facilitate aggressive responses (Krcmar & Lachlan, 2009). Owing to the current lack of evidence regarding the underlying effects and mechanisms, we formulated an explorative research question instead of a hypothesis.

RQ1: Does pace of action in a digital game have an effect on postgame aggressive behavior?

The umbrella term "arousal" is commonly used as a synonym for autonomic responses like HR and SCL. However, arousal as a function of game experience can also be expressed behaviorally, for example, through body movement and postural changes (Bianchi-Berthouze, Kim, & Patel, 2007; van den Hoogen, IJsselsteijn, de Kort, & Poels, 2008). Another behavioral measure that has been used as an indicator of physiological arousal in studies on gaming is the pressure applied to keyboard, mouse, or other input devices. Mentis and Gay (2002) suggest using pressure on input devices as one possible indicator of negative affect, especially frustration. In line with this suggestion, several scholars have shown that pressure increases with the difficulty of a game (Sykes & Brown, 2003; van den Hoogen, IJsselsteijn, de Kort, et al., 2008). As, at least to our knowledge, this measure has not yet been used in studies on the effects of violent content (or pace of action), we did not expect a specific direction of effects, but instead formulated two general research questions.

RQ2: Does game speed have an effect on behavioral measures of arousal during digital game playing?

RQ3: Does displayed violence have an effect on behavioral measures of arousal during digital game playing?

Methods

Design and Procedure

After entering the lab and signing the informed consent, electrodes were attached to the participants' fingers and the mouse. Baseline measures were taken during a briefing about the game's controls and objectives. Participants were told that they would be playing against seven computer-controlled opponents (bots).

We anticipated the difficulty of the game to be a potential confound (Adachi & Willoughby, 2011a). As a wide range of FPS skills and experiences was expected among the participants, setting the difficulty to the same level for everybody was not an option: Skilled players might get bored by an easy game, while a hard difficulty setting could frustrate inexperienced participants. Hence, we decided to adapt the difficulty (enemy AI) to the individual skills of each participant so that they would all be equally challenged by the game. To estimate the subjectively optimal difficulty level, participants were asked to rate their own FPS skills on a scale from 1 to 8. The difficulty of the game was set on this same scale for the first of three warm-up rounds (4 min each). After each warm-up round, the experimenter would enter the room and adjust the difficulty according to performance: If participants won a round by more than three points, the difficulty was increased by one level. If they lost a round and the winning bot had won by more than three, the difficulty was decreased by one level. Otherwise, the difficulty was not changed and the next warm-up was started. When they had finished the three warm-up rounds, the experimenter started the main playing session that lasted 12 min.

After finishing the 12-min session, participants were told that the second part of the experiment was about to start in which they would play 25 rounds of a reaction time (RT) game against a participant in another laboratory. Instructions were also presented on the computer screen before the first trial. Following the CRTT, a browser window in which the questionnaire was presented opened automatically. At the end of the experiment, participants were thanked and debriefed. As an incentive for taking part in this study, 40 games were raffled among all participants.

Sample

Participants (*N* = 87; 60 males and 27 females) were mostly undergraduate and graduate students from the universities of Cologne and Hohenheim (Germany) recruited via the online recruitment tool *Cortex*.[7] Mean age of the participants was *M* = 26.07 years (*SD* = 5.87). Owing to technical difficulties, data from three participants had to be discarded from further analyses, leaving a total of 84, evenly distributed over all four game conditions (nonviolent vs. violent, normal- vs. high-speed).

Materials

Game modification (modding). Modding refers to the practice in which existing digital games are adapted by changing or adding contents of a game. A mod can include or consist of small additions like new items, weapons, models, textures, music, and levels, or change the whole storyline and basic gameplay mechanics. In this study, two features of the futuristic FPS game *Unreal Tournament 3*[8] (UT3) were modified: Violent content and game speed. Game speed was manipulated using the publicly available *UT3 Speed Modification Mutator*.[9] It was either set to the default value of 100% for the normal-speed conditions or to 140% for the high-speed conditions. For the nonviolent conditions, changes were made to several aspects of the game: Instead of the usual death animation involving blood and gore, characters would now drop their weapons, freeze, and become transparent when they were shot. Moreover, for the nonviolent version, the player’s weapon was modified to look and sound like a tennis-ball shooting nerf gun. Finally, the pain screams of the player’s avatar and all opponents were disabled and aggressive language was removed in the nonviolent conditions by deactivating the verbal messages from the computer-controlled characters (bots) and editing the on-screen messages (e.g., after “killing” an opponent). According to the categorization of violent media content by Tamborini et al. (2013), we only manipulated the graphicness of displayed violence. Neither the justification nor the realism of the violence was varied systematically. See Figure 1 for sample screenshots from the violent and nonviolent version.

Aggressive behavior. We used the standardized version of the CRTT suggested by Ferguson et al. (2008) to measure aggressive behavior. In this version of the test, participants are told that they are playing an RT

[7] Elson, M., & Bente, G. (2009). *CORTEX - Computer-Aided Registration Tool for Experiments*. University of Cologne, Germany. Retrieved from http://cortex.uni-koeln.de
[8] Epic Games. (2007). *Unreal Tournament 3*. Chicago, IL: Midway Games.
[9] Chatman, B. (2008). *UT3 Speed Modification Mutator*. Retrieved from http://www.moddb.com/

Figure 1. Sample screenshot from the violent (top half) and nonviolent (bottom half) experimental conditions.

game on a computer against another participant, in which they have to press the space bar as fast as possible after hearing a sound signal. Before each of the 25 trials, participants have to set the volume and duration of a noise blast their opponent will hear in case of losing that round on a scale from 1 to 10. They are told that their opponent will set the volume and duration of a noise blast as well. If the participant loses a round, he or she hears a noise blast with the settings allegedly chosen by the opponent. The settings chosen by their "opponent" are shown on screen after each trial. In reality, there is no other participant and the sequence of wins and losses, volume and duration settings are randomized and preset. The first trial is always a loss, and the opponent's settings are volume 5, duration 5. After that, there are 12 wins and 12 losses over 24 trials with volume and duration settings ranging from 2 to 9. The volume output is calculated by multiplying a fixed factor with the volume setting. As it was technically not possible for us to measure the exact headphone volume in decibels, we determined the maximum setting (unpleasantly noisy but not painful) in a pretest, and scaled the lower settings linearly from that point. The duration was increased linearly by 250 ms multiplied with the duration setting (i.e., 250–2,500 ms). The whole test was administered with *Presentation*.[10]

Physiological arousal (autonomic). HR and SCL were used as measures of autonomic arousal in this study. Both were recorded with the Wild Divine IOM Lightstone Biometrics USB Widget. This device provides three plastic finger clips, two for SCL, and one for HR. The clips were attached to the player's thumb, ring finger, and middle or left finger (for right-handed and left-handed players, respectively). The IOM's plastic cases and the mouse used to control the game were wrapped with hook-and-loop tape, sparing only the left mouse button.

Physiological arousal (behavioral). To measure body movement, we connected a Nintendo Wii Fit Balance Board to a computer via Bluetooth and placed it on a wooden chair on which the participants were required to sit on during the experiment. The Balance Board is shaped like a household body scale, but instead of one it has four sensors, one in each corner. Shifts in posture or movement increase the weight on one sensor while decreasing the weight on the others. Accordingly, body movement was calculated from the variance in the sensor data.

Pressure was measured with seven SparkFun Force-Sensitive Resistors (FSRs). These FSRs change their resistance depending on how much pressure is applied to the 0.5-inch (12.7 mm) sensing area. The sensors were fixed on all keys on the keyboard and mouse that were used to control the game and connected to a LabJack U3 Low Voltage hub, which transforms the input from the sensors into voltage data with a range of 0 to 2.5 V and provides a digital output via USB.

Additional measures. The participants' gaming expertise was expected to be an important and possibly moderating variable for all of the dependent variables. Participants rated their

[10] Neurobehavioral Systems. (2010). *Presentation (14.5)*. Albany, CA: Neurobehavioral Systems.

Table 1
Rotated Component Matrix of the Manipulation Check Items[a]

Item	Factor 1	Factor 2
Violence		
You had to use physical violence in this game.	.848	
The characters in this game were hurt.	.894	
Physical damage was inflicted on the characters in the game.	.878	
You had to kill humans in this game.	.796	
Pace of action		
The characters moved unnaturally fast in the game.		.689
The characters in the game moved with superhuman speed.		.632
The movements in the game were so hectic that sometimes I could not follow them.		.778
The speed of the game was too high to play it reasonably.		.658

Note. Extraction method: Principal component analysis. Rotation method: Varimax with Kaiser Normalization.
[a] Rotation converged in three iterations.

expertise by stating the average frequency of their FPS use during the last 12 months on a 9-point ordinal scale (ranging from *never* to *several times a day*). The measured game expertise did not have an effect on any of the dependent variables and will thus not be further discussed in the results section.

A set of ad hoc items was used to check for a successful manipulation of the game variables speed and violence. Participants rated eight items on a 7-point Likert scale from *not applicable at all to fully applicable* (see Table 1 for a factor analysis of these items). For the second manipulation check (only of violent content), participants had to assign an age rating to the game they just played. Because the study was conducted in Germany, the participants rated the game according to the 2009 rating criteria of the German rating board for digital games.[11] Participants could choose between *no age restriction*, restrictions for those below the age of 6, 12, 16, 18, and no clearance.

Manipulation Checks

Mean scores for perceived violence and perceived speed were computed from the respective items (see Table 1). One-way ANOVAs showed a successful manipulation of violence, $F(1, 80) = 23.88$, $p < .001$, $\omega^2 = .21$; and speed, $F(1, 80) = 19.90$, $p < .001$, $\omega^2 = .18$. A Mann–Whitney U test revealed that participants in the violent conditions chose a significantly higher age rating ($Mo = 16$) than participants in the nonviolent conditions ($Mo = 12$), $U = 385.50$, $z = -4.80$, $p < .001$, $r = -.52$.

Results

Aggressive Behavior

Following the procedure suggested by Ferguson et al. (2008), volume and duration were first correlated to investigate whether they would both measure the same construct (i.e., aggression). The volume and duration measures for each trial showed a medium-size significant correlation, $r = .44$, p (one-tailed) $< .001$. The correlation of average volume and duration measures for each participant was substantially higher, $r = .71$, p (one-tailed) $< .001$.

Using separate ANOVAs, no significant main effects on the mean volume settings were found for game speed, $F(1, 80) = 0.98$, $p = .324$, $\omega^2 = .0$; displayed violence, $F(1, 80) = 3.28$, $p = .074$, $\omega^2 =.03$; or game speed X displayed violence, $F(1, 80) = 0.83$, $p = .364$, $\omega^2 = .0$.

No significant main effects on the mean duration settings were found for game speed, $F(1,80) = 0.07$, $p = .784$, $\omega^2 = .0$; displayed violence, $F(1, 80) = 0.95$, $p = .334$, $\omega^2 = .0$; or the interaction between speed and violence, $F(1, 80) = 1.70$, $p = .196$, $\omega^2 = .01$.

These results provide an answer to hypothesis *H1* and research question *RQ1*: Individuals who played the violent version of the digital game did not act more aggressively in a subsequent behavioral test than individuals who played a nonviolent version. Game speed had

[11] Unterhaltungssoftware Selbstkontrolle; see http://www.usk.de

no such effect either. There was also no systematic interaction between the two variables.

Physiological Arousal

Skin conductance level and heart rate. No significant main effects on mean SCL were found for game speed, $F(1, 80) = 0.25$, $p = .616$, $\omega^2 = .0$; and displayed violence, $F(1, 80) = 1.75$, $p = .189$, $\omega^2 = .01$; but there was a significant interaction effect, $F(1, 80) = 4.42$, $p = .039$, $\omega^2 = .04$. Looking at the significance of simple effects, participants in the normal-speed X nonviolent condition had a significantly higher average SCL level than those in the normal-speed X violent condition, $F(1, 80) = 5.87$, $p = .018$.[12]

No significant main effects on the HR mean were found for game speed, $F(1, 80) = 0.37$, $p = .546$, $\omega^2 = .0$; displayed violence, $F(1, 80) = 0.00$, $p = .965$, $\omega^2 = .0$; and game speed X displayed violence, $F(1, 80) = 0.17$, $p = .680$, $\omega^2 = .0$. Hence, these results provide no evidence for hypotheses *2* and *3*: Individuals who played a high-speed digital game did not show higher tonic SCL or HR levels during play than individuals who played a normal-speed digital game. The displayed violence also did not affect tonic levels of SCL or HR. There was, however, a significant interaction of the two variables showing that SCL levels were the highest when there were no displays of violence and a normal pace of action.

Body movement. Heavier participants would cause shifts in the weight sensors more easily than lighter ones, so the movement data had to be transformed and standardized. Each absolute measure was divided by the participant's weight. The variance from this relative figure was calculated and averaged for all four sensors and the square root was extracted. This final score, the relative mean standard deviation, was used as the body movement score for each participant.

There was a significant main effect of game speed, $F(1, 80) = 10.47$, $p = .002$, $\omega^2 = .10$; and an interaction effect of game speed X displayed violence, $F(1, 80) = 5.42$, $p = .022$, $\omega^2 = .05$; but no significant main effect of displayed violence alone, $F(1, 80) = 2.01$, $p = .160$, $\omega^2 = .01$. There were two significant simple effects: Participants in the normal-speed X nonviolent condition showed significantly more body movement than participants in the high-speed X nonviolent condition, $F(1, 80) = 15.48$, $p < .001$; and in the normal-speed X violent condition, $F(1, 80) = 7.02$, $p = .010$.

Based on these findings, the first part of the answers to research questions *RQ2* and *RQ3* is as follows: Individuals who played a normal-speed digital game showed more body movement, but only when the game was nonviolent. Although there was no significant main effect, displayed violence did have an effect on body movement that interacted with the effect of game speed.

Pressure. To analyze the data from the pressure sensors, all output values below 0.3 V had to be discarded, as it was possible to apply that much pressure on the mouse without actually clicking any buttons. The average pressure applied to all keys pressed in each measurement point was calculated (for diagonal movement, e.g., players have to press W/S or A/D at the same time). This average was then *z*-transformed for each participant. There was a significant main effect of game speed, $F(1, 80) = 4.06$, $p = .047$, $\omega^2 = .03$; and displayed violence, $F(1, 80) = 14.24$, $p < .001$, $\omega^2 = .12$; but no significant interaction of the two, $F(1, 80) = 0.05$, $p = .830$, $\omega^2 = .0$. There were two significant simple effects: Participants in the high-speed X violent condition applied significantly more force than those in the high-speed X non-violent condition, $F(1, 80) = 6.33$, $p = .014$. Also, participants in the normal-speed X violent condition applied significantly more force than the normal-speed X nonviolent players, $F(1, 80) = 7.96$, $p = .006$. Hence, the second part of the answers to research questions *RQ2* and *RQ3* can be summed up as follows: Individuals who played a violent digital game applied more pressure on mouse and keyboard during play than individuals who played a nonviolent digital game. Individuals who played a high-speed digital game applied more pressure on mouse and keyboard during play than individuals who played a normal-speed digital game.

Discussion

In sum, we found that neither displayed violence nor game speed had any significant effect

[12] Note that for all reported simple effect analyses we used Sidak corrections for multiple comparisons.

on postgame aggressive behavior. There was a small effect on autonomic arousal, showing that SCLs were the highest when playing a normal-paced nonviolent game. The effects on behavioral arousal were more pronounced: Playing a fast-paced game inhibited participants' body movement, particularly when the game was nonviolent. A higher pace of action and displays of violence also caused players to exert greater pressure on the input devices. These findings will be discussed in greater detail below.

Displayed Violence

There are several possible explanations why we did not find that displayed violence had any effect on aggressive behavior: It could be that playing a violent digital game does not increase subsequent aggressiveness (as measured by the CRTT). This finding is in line with some research reports (Valadez & Ferguson, 2012), whereas it contradicts others (Anderson et al., 2004). Second, the manipulation may not have been strong enough. Maybe the representational action of hitting or shooting an opponent alone, and not the actual game content, was sufficient to diminish differences in aggressiveness between all conditions (i.e., a ceiling effect), although the manipulation check indicated a substantial difference between the violent and the nonviolent conditions. This, however, would imply that the graphicness of violence might be less of a concern than other variables.

Even without the violence, all versions of the game were still competitive, which can be another cause for postgame aggression (Adachi & Willoughby, 2011b). Regardless of whether or not displayed violence actually increases aggressiveness, however, another explanation for the absence of differences could be that the CRTT is not a valid and reliable measure for aggressive behavior. Several concerns regarding its validity and lack of standardization in particular have been brought up (Ferguson, 2011, 2013; Tedeschi & Quigley, 1996). This concerns should be taken seriously when discussing the findings from studies using these tests, especially against the background of the recent debate about "methodological flexibility" in psychology (Simmons, Nelson, & Simonsohn, 2011). In fact, we ourselves are far from convinced of the CRTT's merits in aggression research. The reason why we still opted for it in the present study relates was to show that the potential confounds we were interested in (such as pace of action) can affect common or "default" laboratory measures of arousal and aggression.

The analysis of average HR and SCL revealed no systematic differences between the experimental conditions. Displayed violence alone did not affect HR and SCL at all, but SCLs while playing a normal-paced game were significantly higher when it was nonviolent. HR was not different in this condition from any of the others. Although there seems to be a potentially relevant interaction here, this particular finding is hard to explain in the light of general theoretical models or previous findings. The fact that violence did not have a systematic effect is in line with some studies (Anderson et al., 2004), whereas it also opposes others (Anderson & Carnagey, 2009). One possible explanation is that slight differences in a third variable, such as the game's theme (toy guns vs. futuristic weapons), caused the unexpected pattern. This would also support our call for an even more rigorous manipulation of the stimulus material.

There were, however, some clear results with regard to the behavioral measures of physiological arousal. Although displayed violence did not have a main effect on body movement, it interacted with the effects of game speed (see below). Whether this interaction is systematic, and how the mechanisms behind a possible link between violence and body movement would work, remains subject to further research. Although applying pressure certainly is a behavior that can be controlled, it might also happen involuntarily during a complex task like playing a digital game. Stronger displays of violence did in fact increase the pressure that players applied to mouse and keyboard significantly. The threat of a gory death of the player's avatar might add more suspense to the game than just being hit by a tennis ball. Even the sheer sight of a virtual weapon could have an impact on the player experience possibly expressed through pressure (Anderson, Benjamin, & Bartholow, 1998; Berkowitz & LePage, 1967).

Game Speed

There was neither a main effect of game speed on aggressive behavior nor a systematic interaction effect with displayed violence. If we keep the assumption that the CRTT is a valid measure for aggressive behavior, this would mean two things: First, aggressive behavior does not seem to be affected by differences in pace of action. Second, this finding suggests that the role of pace of action in media effects research might be less important than assumed (Adachi & Willoughby, 2011a). Given the complex interplay of different game characteristics, however, it is possible that pace of action might have a more pronounced effect when interacting with certain other variables, for example, in particularly competitive games. Using modding to systematically manipulate or control for other variables might be a good starting point for further research.

As with displayed violence, higher pace of action did not produce an increase in HR and SCL. This was quite puzzling to us, given that rapidly moving media images reportedly have strong physiological effects, including cases of motion sickness (Stoffregen, Faugloire, Yoshida, Flanagan, & Merhi, 2008). A possible explanation might be that the game speed was too high in all four conditions, effectively mitigating measurable differences between the individual conditions. The differences between violent and nonviolent games are usually measured by using a violent fast-paced FPS for the one group, and a nonviolent and probably slower-paced game for the other. However, in this study, all groups played an FPS game; two groups even played with an increased speed. It is thus possible that all conditions induced a somewhat similar change in arousal, or that a third variable that was not controlled for (e.g., the theme of the game or the purpose of the matches played) led to the highest increase in the normal-paced nonviolent condition.

A fast-paced game like an FPS is demanding on the player in terms of visual attention, reaction speed, hand– eye coordination, and motor skills. Unnecessary body movement can put players' performance at risk, even more so with the additional challenge of increased speed. Indeed, our results show that the faster the game, the less postural change occurred. However, there was an interaction with the effects of displayed violence: Participants showed more body movement when they were playing a normal-paced digital game, but only when that game was nonviolent. Whether displays of gore could cause participants to "freeze" involuntarily is something to consider, for example. It is also possible that the increased cognitive demand on players when playing a high-paced game where the consequences of failure are seen as more severe or graphical (e.g., the death of the player avatar) might lead to an increased focus of attention and, thus, to less body movement. Because body movement itself is correlated with other biological responses, it becomes clearer that caution is necessary when interpreting psychophysiological data. The relations between stimuli, perception, and biological responses are so complex that a mono-causal and direct link between violent games and general arousal seems rather unlikely.

There was a significant main effect of game speed on pressure applied to the input devices. The faster or more violent the game, the harder participants pressed on keyboards and mouse. We assume that is due to the greater demands on the participants' reaction capabilities, as a faster game requires players to hit all buttons at a faster rate, essentially a trade-off with precision and fine motor abilities. "Button mashing" could also be an effect of growing muscular exhaustion of the participants in the high-speed conditions. The findings on pressure are also in line with those on body movement. Increased pace of action requires players to focus their attention and to literally "try harder." This leads to an increased pressure on input devices. Our main conclusion here is that, in context of the existing literature on effects of digital game playing and explanatory models like the General Aggression Model (Anderson & Bushman, 2002), it appears that we need a more refined understanding of the term "arousal" and the different forms, physiological and behavioral, it might be expressed through (Blascovich, 1990; van den Hoogen, IJsselsteijn, & de Kort, 2008).

Limitations

There were several limitations with this study. The sample we used was composed exclusively of university students. The results obtained in our study might be different for other populations. There sample was also not balanced for gender (60 males and 27 females), potentially limiting the study's generalizability. However, given that FPS games are more popular among male gamers in Germany (Quandt, Scharkow, & Festl, 2010), this lapse might be less critical. Because we only used one game in our study, the findings can also not be easily generalized for other games with different levels of graphicness, realism, and justification for on-screen violence (Tamborini et al., 2013). Moreover, the nonviolent conditions still involved combat, albeit with nonviolent results. Because there is little research on the differential effects of graphical versus symbolic violence, this is a limitation to be considered. With regards to the findings on aggressive behavior, it is important to note that the results gained with the CRTT have to be interpreted with caution for reasons discussed above. The experimental situation demands aggressive reactions, as participants are instructed to behave aggressively in the CRTT; the aggressive acts cause no physical harm and are not sanctioned (Ferguson & Rueda, 2009; Tedeschi & Quigley, 1996). In addition, administering noise blasts is a behavior that is rather rare in real life, and the target of the aggressive behavior was not visible and unknown to the participants (Ferguson, 2013).

There might also be other factors in this study that could affect physiological arousal or aggressive behavior, such as the competitiveness of the game (Adachi & Willoughby, 2011b), frustration (e.g., caused by an unfamiliarity with the controls), or the outcome of the game, that is, the player's success.

Moreover, we only looked at limited arousal dimensions in our study. Additional assessments of the quality (valence) of emotions, for example, via self-report or the analysis of facial expressions, are likely to provide further insights into the effects that individual game characteristics can have on the experiences and emotional states of players.

Conclusion and Future Research

This study set out to explore potentially confounding effects of conflating variables when working with digital games as stimuli in experiments. The results show that game speed, a feature that tends to vary across games and genres, not only interacts with displayed violence, but also has a direct effect on several outcome variables that might otherwise be misleadingly attributed to displayed violence. The findings of this study demonstrate the importance of controlling potentially confounding factors in experimental research on digital games and points to the importance of further systematic research into what other variables of a game may affect player experience and behavior (Elson, Breuer, & Quandt, in press). This study also shows that game modifications offer a potential solution for researchers trying to accomplish a more rigorous manipulation of their variables while maintaining control over others, thus increasing the internal validity of the experiments.

It would be interesting to extend the experimental research on the effect of pace of action by another level of speed that is substantially slower than normal, and investigate whether any setting of game speed actually affects SCL and/or HR. Experimental investigations of the effects of other game characteristics, such as competitiveness or difficulty, and their interaction can help to improve our understanding of the causal mechanism at work when cognitive, emotional, or behavioral effects of digital games are assessed. Systematically manipulating other dimensions of violence, such as the realism or justification (Tamborini et al., 2013), could also be a promising branch for research on the effects of digital games. In addition, the continuation of this line of work can help in making the right choices for the stimulus selection. The results of the present study strongly suggest that mono-causal attributions of effects can be misleading (Ferguson, 2013; Jenkins, 2006). A rigorous control of the stimulus materials used in experiments on and with digital games is vital to draw the proper conclusions about the effects of media contents on their users.

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