



The effect of violent video games on aggression: Is it more than just the violence? ☆

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ARTICLE INFO

Article history:
 Received 15 October 2009
 Received in revised form 12 September 2010
 Accepted 6 December 2010
 Available online 15 December 2010

Keywords:
 Violent video games
 Aggressive behavior
 Competitiveness
 Violence

ABSTRACT

Experimental research has shown that playing violent video games produces higher levels of aggressive cognition, aggressive affect, physiological arousal, and aggressive behavior (in the short-term) than non-violent video games. However, there are two major limitations with these investigations. First, the majority of experimental studies that have compared the effects of violent versus non-violent video games on aggression have failed to equate these games in terms of competitiveness, difficulty, and pace of action. Thus, although the common finding is that violent video games produce higher levels of aggression than non-violent video games, other unmatched factors beyond the actual violent content may be responsible for the elevated levels of aggression. Second, previous experimental studies have tended to use a measure of aggression that may also measure competitiveness, leading to questions about whether violent video games are related to aggression or competitiveness. After describing these two limitations, how future research can address these gaps in the violent video game literature, and why this research is important, are discussed.

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The horrific shooting sprees by frequent violent video game players at Columbine High School in 1999 and Virginia Tech in 2007, as well as the “Beltway” sniper shootings in 2002 led to increased public scrutiny of the effects of violent video game play. Of course, such accounts are not scientifically grounded and, thus, cannot provide adequate support for public policy decisions nor links between violent video game play and relevant scientific theories of aggression (Anderson, 2004). Nevertheless, in the past two decades, several correlational studies involving adolescents and young adults have found a small but significant relation between playing violent video games and aggression (see Anderson & Bushman, 2001; Dill &

Dill, 1998), with aggression defined as behavior that is intended to harm another individual (Coie & Dodge, 1998). In addition, experimental research examining short-term effects has shown that playing violent video games produces higher levels of aggressive behavior (in the short-term), aggressive cognition, aggressive affect, and physiological arousal than non-violent video games (see Anderson, Gentile, & Buckley, 2007).

The effect of violent video games on aggression is a relevant issue as video games have become very popular. For example, a nationally representative study of video game play among adolescents in the United States showed that 97% of adolescents aged 12 to 17 years play computer, web, portable, or console video games (Lenhart et al., 2008). In terms of frequency, 31% of adolescents play video games every day and another 21% play games three to five days a week. Yet, what may be most concerning is that almost half of the adolescent population plays violent video games. In addition, five of the 10 most frequently played games are violent. Thus, research is needed to examine the effects of violent video games on aggression.

☆ The second author acknowledges funding received from the Social Sciences and Humanities Research Council of Canada as well as Owl Children's Trust.

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In spite of the increasing experimental research examining the effects of violent video games on aggression, there are two major limitations with these studies. First, the majority of experimental studies that have compared the effects of violent versus non-violent video games on aggression have failed to equate these games in terms of competitiveness, difficulty, and pace of action. Although the common finding is that violent video games produce higher levels of aggression than non-violent video games, it may be that violent video games are also more competitive, difficult, and contain more fast-paced action than non-violent games. Consequently, it is unclear whether the violent content alone is responsible for elevated levels of aggression. Second, previous experimental studies have tended to use a measure of aggression that may also measure competitiveness, leading to questions about whether violent video games are related to aggression or competitiveness. This review elaborates on both of these limitations and starts by outlining a model for how video games might affect aggression.

1. The General Aggression Model

Anderson and Bushman (2002) developed the General Aggression Model (GAM) in part to account for the effects of violent video games on aggression (see Fig. 1; also Anderson & Bushman, 2002; Anderson & Carnagey, 2004 for a detailed description of the model). The model depicts a cyclical relationship between an individual and the environment, in which person variables such as trait hostility, mood, and attitudes toward aggression, as well as situation variables, such as exposure to real-world or media violence (e.g., violent video games), interact to influence an individual's present internal state, specifically cognition (aggressive scripts or hostile thoughts), affect

(anger and frustration), and arousal (elevated heart rate or blood pressure). Cognition, affect, and arousal are the hypothesized mechanisms that interact to influence an individual's appraisal of an aggressive (or ambiguous) act, leading to either thoughtful or impulsive action. For example, if someone bumps into another individual, that individual's internal state will influence whether he or she interprets the person as having hostile intent, or perceives the bump as being accidental. When people's thoughts and feelings are angry or hostile and they are physiologically aroused (e.g., after exposure to a violent video game), they will be more likely to interpret the person as having hostile intent. In contrast, if their affect is positive or they are thinking about how crowded the room is, they will be more likely to believe the bump was accidental. Once an appraisal has been made, decision-making processes occur (outcomes). Depending on the individual's internal state and the availability of sufficient cognitive resources, a decision will be made either thoughtfully or impulsively. If he or she interpreted the person as bumping into him or her with hostile intent, he or she may be more likely to aggress than to ignore the bump, especially if this decision was made impulsively (social encounter).

According to Anderson and Bushman (2002), violent video games influence aggression through short-term and long-term effects. In the short-term, violent video games function as a situation variable that can increase aggressive cognition, affect, and arousal, in turn leading to increased aggressive behavior. In the long-term, violent video games can influence aggressive behavior by promoting aggressive beliefs and attitudes, and creating aggressive schema, aggressive behavioral scripts and aggressive expectations; which, in turn, may bias an individual's personality toward aggression. In other words, each violent video game episode may reinforce the notion that

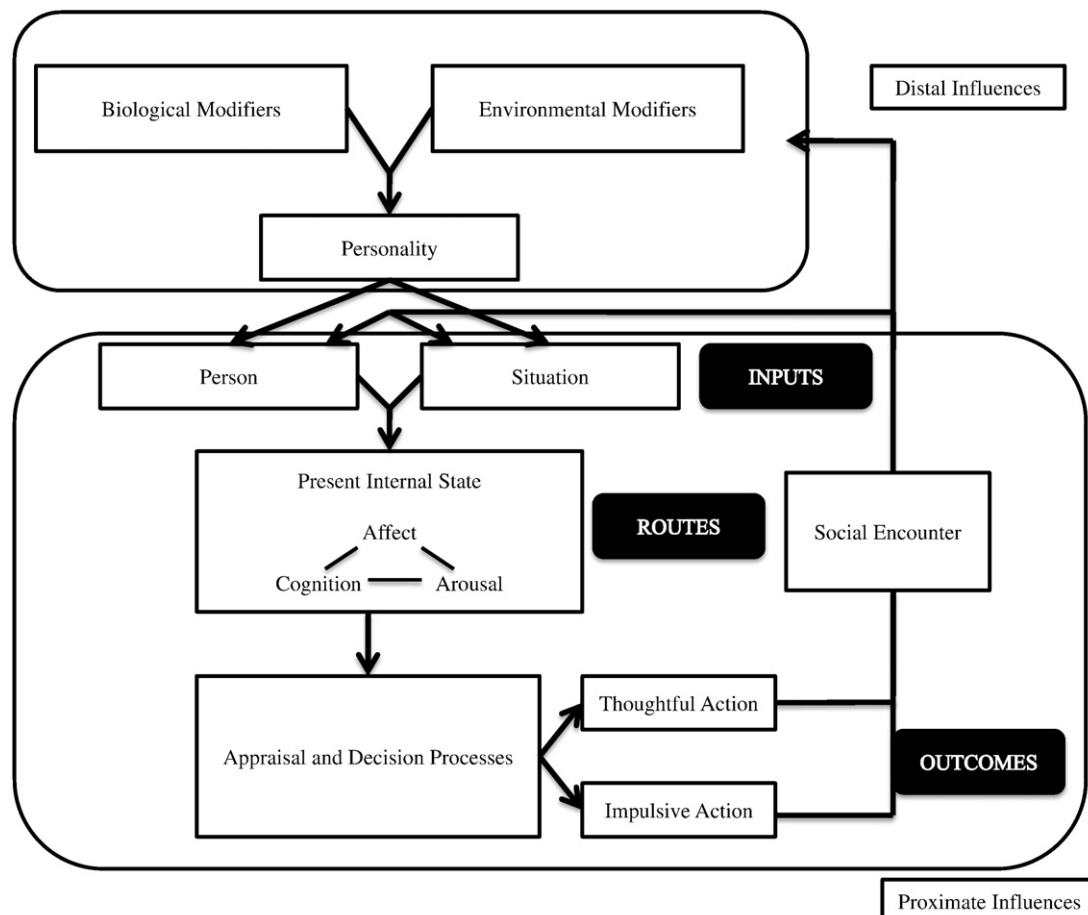


Fig. 1. An overall view of the General Aggression Model. From Anderson and Carnagey (2004).

aggression is an effective and appropriate way to deal with conflict and anger (Bushman & Anderson, 2002).

2. Empirical background

2.1. The influence of violent versus non-violent video games on aggression

Experimental studies examining the short-term effect of violent video games on aggression have typically involved randomly assigning participants to play either a violent or non-violent video game, followed by a measure of aggression (e.g., Anderson & Carnagey, 2009; Bushman & Anderson, 2002). Participants in the violent video game condition have shown more aggression than participants in the non-violent condition for both males and females in a majority of studies (e.g., Anderson et al., 2007, but see Ferguson, Rueda, et al., 2008). For example, Anderson and Dill (2000) conducted an experiment in which they examined the effects of violent video game play on aggressive thoughts and behavior. Participants from an undergraduate sample were randomly assigned to play either a violent or non-violent video game in two laboratory sessions. In the first session, participants completed a measure of aggressive thoughts immediately after playing the video game. The measure was a reading reaction time task in which aggressive words, such as “murder,” were paired with three types of control words (i.e., anxiety, escape, and control). Results indicated that only participants who played the violent video game reacted faster to the aggressive words than the control words. Thus, Anderson and Dill concluded that the violent video game primed aggressive thoughts. Furthermore, consistent with the GAM, priming aggressive knowledge structures is one potential path through which playing violent video games might increase aggressive behavior.

In the second laboratory session, aggressive behavior was measured immediately after playing the video game using a modified version of the Taylor Competitive Reaction Time Test (TCRTT), in which the participant's goal was to push a button faster than his or her opponent over a number of trials. If the participants lost a trial, they received a noise blast which they believed was set by their opponent, and if the participants won, they set the level of noise blast to be administered to their opponent. Aggressive behavior was operationally defined as the intensity and duration of noise blasts that the participants chose to deliver to their opponent. Results showed that participants who played the violent video game delivered significantly longer noise blasts (after “loss” trials) than participants who played the non-violent video game.

Similarly, playing violent video games led to increased aggression in an experiment that used a repeated measures design. Barlett, Harris, and Baldassaro (2007) took baseline measures of undergraduate participants' physiological arousal, state hostility, and aggression and then exposed them to a violent video game for 15 min. Aggression was measured using story stems in which participants took the point of view of the main character and were asked how they would retaliate after a blatant negative action. After playing the game, physiological arousal, state hostility, and aggression were once again recorded and significant increases from baseline were found in all three measures. Thus, it was concluded that consistent with the GAM, physiological arousal, state hostility and aggression were higher than baseline after playing a violent video game for only 15 min. However, since a non-violent video game was not used in this study, it is unclear whether a non-violent video game would have also produced elevated levels of physiological arousal, state hostility and aggression, similar to the violent video game.

Field studies have also supported the relation between violent video games and aggression (see Anderson et al., 2007). For example, Gentile, Lynch, Linder, and Walsh (2004) conducted a correlational study with 8th- and 9th-grade students (mean age = 14 years) and

found that adolescents who played more violent video games reported being more hostile, getting into arguments with teachers more frequently, and being involved in more physical fights than adolescents who played less violent video games. Consistent with the GAM, it was found that hostility partially mediated the relation between violent video game play and involvement in physical fights, and fully mediated the relation between violent video game play and reported arguments with teachers. In addition, Fling et al. (1992) found that video game play was correlated with both teachers' rating of aggression and self-reported aggression among a sample of sixth through twelfth grade students. Such correlational findings suggest that the short-term effect of violent video game play on aggression found in experimental studies may generalize to the real world. However, due to the correlational design of such studies, it is unclear whether the results indicate that children who played more violent video games then became more aggressive or children who were more aggressive played more violent video games.

Although several studies have found a short-term effect on aggression from violent video game play, only one study has examined the length of these short-term effects (Barlett, Branch, Rodeheffer, & Harris, 2009). In the first of two experiments, the length of short-term violent video game effects on physiological arousal, aggressive thoughts, and hostility was examined using an undergraduate sample. Physiological arousal was measured using heart rate, hostility was measured with a state hostility questionnaire, and aggressive thoughts were measured using a word completion task. Arousal, hostility and cognition were measured immediately after playing the video game, and then again after either a 4-minute or a 9-minute delay.

Participants were told they were in two unrelated studies looking at video game play and food preference. Upon entering the lab, they had their heart rate measured three times to assess baseline heart rate and then completed the state hostility scale and a word completion task. They were then randomly assigned to play either a violent or nonviolent video game for 15 min. Immediately after playing the video game, participants again had their heart rate measured and were given the hostility questionnaire and a different word completion task. They then completed a Hot Sauce Paradigm, designed to measure aggression.

In the Hot Sauce Paradigm, the participant was given an already completed food preference questionnaire and told that another participant down the hall had completed this questionnaire and as indicated by the questionnaire, did not like spicy food. The participant was then brought to a table that had hot sauce, popsicle sticks, cups, and a spoon and was informed that his or her job was to mix up some hot sauce for the other participant to drink. The amount of hot sauce in the cup and the degree of hotness was indicative of overt aggressive behavior.

After the participant completed the hot sauce task, the researcher explained that he would be back momentarily. For those assigned to the 4-minute condition, the experimenter left the room, placed the cup of sauce in the hall and then returned immediately, as at this point 4 min had elapsed since the end of the video game. For participants in the 9-minute condition, the experimenter left the room with the cup of sauce and returned without the cup exactly five minutes later, which was 9 min after the end of the video game. When the experimenter returned, all participants completed a packet of questionnaires including the hostility scale and a new word completion task. Their heart rate was also measured, and participants were told that if they saw the same questionnaires as before, it was because the two studies (video game play and food preference) were looking at similar variables.

Change scores were computed between time 2 (immediately after video game play) and baseline measures of physiological arousal, hostility and aggressive thoughts, and the results showed that these three variables increased more after playing the violent video game

than after playing the non-violent video game. Participants who played the violent video game also prepared more of a hotter sauce than those who played the non-violent video game. In terms of the length of short-term effects, no matter what the delay, by the time the Hot Sauce Paradigm was completed, participants' levels of aggressive thoughts and hostility returned to baseline. Thus, the short-term effect of violent video games on aggressive thoughts and feelings lasted less than 4 min. However, there was a significant delay by content interaction for physiological arousal, and further analysis showed higher than baseline average heart rate at the 4 min delay, and slightly lower than baseline average heart rate at the 9 min delay. Therefore, the effect on arousal lasted more than 4 min but less than 9 min.

The second experiment looked specifically at the length of short-term violent video game effects on overt aggressive behavior. The procedure was similar to the first study, except that participants completed the Hot Sauce Paradigm 0, 5, or 10 min after violent video game play and aggressive thoughts, feelings and physiological arousal were not measured. A non-violent condition was not included in this study. The results showed that participants in the 0-minute and 5-minute conditions had significantly higher aggressive behavior scores than those in the 10-minute condition. Also, there was no significant difference between the 0- and 5-minute conditions. Thus, the effect of playing a violent video game on aggression lasted between 5 and 10 min.

The research findings presented in this literature review appear to offer a clear picture of the short-term relation between violent video games and aggression; however, there are two limitations that have yet to be concurrently addressed in a single study. The first limitation is that dimensions related to aggression other than violence, such as competitiveness, difficulty, and pace of action have not been equated between violent and non-violent video games in the majority of experimental studies examining the effects of violent video games on aggression. The second limitation is that the majority of experimental studies examining the effects of violent video games on aggression have used an ambiguous measure of aggression that has been used inconsistently across studies. Each of these limitations will be reviewed in turn.

2.2. Differences other than violence between violent and non-violent video games

The first limitation is that the majority of studies examining the effects of violent video games on aggressive behavior have not attempted to equate the violent and non-violent games on other dimensions that may be related to aggression, such as competitiveness. For example, violent video games in general tend to be more competitive than non-violent video games (Carnagey & Anderson, 2005). Consequently, studies that have found that violent video games produced more aggression than non-violent video games, but failed to equate the games on competitiveness, cannot conclude that the violent content alone was responsible for the elevated levels of aggression.

Anderson and colleagues also have recognized this issue and have made significant attempts to equate the violent and non-violent games on many dimensions such as physiological arousal, excitement, difficulty, and frustration level (Anderson & Carnagey, 2009; Anderson & Dill, 2000; Anderson et al., 2004). However, recall that according to GAM, video game violence may influence aggressive behavior by elevating physiological arousal, aggressive cognition, and aggressive affect. Thus, some of the video game dimensions that Anderson and colleagues have attempted to match are not actually characteristics of the video games themselves, but instead are variables related to one's internal state. These internal states, according to the GAM, are hypothesized, to be *outcomes* or *consequences* of playing violent video games. For instance, consistent

with the GAM, the violent content in a violent video game may produce elevated levels of physiological arousal compared to a non-violent video game, which in turn can influence aggressive behavior. Controlling for physiological arousal level, therefore, may not make the relation between video game violence and aggression any clearer; instead, it may weaken the relation between the two variables as physiological arousal is a mechanism through which video game violence is thought to impact aggression. In other words, variables related to one's internal state (i.e., physiological arousal, aggressive cognition, and aggressive affect) should not be controlled as they are mechanisms through which video games may influence aggression.

In order to address the issue of whether the violence alone in violent video games produces more aggressive behavior than non-violent video games, it is important to differentiate between: 1) characteristics of the video game, and 2) internal state variables. We propose that violence, competitiveness, difficulty, and pace of action are four main video game characteristics that may influence aggressive behavior through the mechanisms of internal state variables such as physiological arousal, aggressive cognition, and aggressive affect (see Fig. 2). Competitiveness may influence aggressive cognitions by activating associative links between aggression and competition developed through a variety of past experiences with competitive situations that have resulted in aggressive outcomes (Anderson & Carnagey, 2009; Anderson & Morrow, 1995). Competitiveness may also influence physiological arousal and aggressive affect, such as frustration or hostility. Difficulty may influence physiological arousal, frustration, and hostility. For example, games that are more difficult tend to produce more frustration (Anderson & Carnagey, 2009). In addition, pace of action may be linked to physiological arousal, with faster games leading to elevated levels of physiological arousal. To date, no study has equated a violent and non-violent video game on competitiveness, difficulty, and pace of action. Thus, it is unclear whether it is the violence in violent video games that has produced elevated levels of aggression compared to non-violent video games, or whether it is these other game characteristics that may have been responsible.

Only a few studies have attempted to match the violent and non-violent video games on confounding dimensions. For example, in order to choose video games for their main experiment which was previously described, Anderson and Dill (2000) conducted a pilot study in which they attempted to match a violent and non-violent video game on other dimensions beyond violence that may be relevant to aggressive behavior. The dimensions included blood pressure, heart rate, frustration, difficulty, action pace, enjoyment, and excitement. The best pairing was between the violent video game *Wolfenstein 3D* and the non-violent video game *Myst*, which matched on all of the dimensions except for excitement, with *Wolfenstein 3D* rating higher. Although both difficulty and action pace were matched, Anderson and Dill failed to equate the games on competitiveness. The violent video game *Wolfenstein 3D* is a first-person shooter game that involves shooting and stabbing Nazi soldiers in order to escape from a Nazi prison. The main character must compete with each opponent character in a battle for survival in order to complete the game. However, in the non-violent video game *Myst*, the main character does not compete with any other characters in the game, and instead must solve a series of puzzles in order to advance through the levels. Therefore, participants who played *Wolfenstein 3D* may have felt more competitive than participants who played *Myst* and thus, behaved more aggressively. Furthermore, the modified TCRTT which was used to measure aggressive behavior may actually measure competitiveness, which further explains why participants who played *Wolfenstein 3D* administered more intense punishments than those who played *Myst*. This problem with the modified TCRTT will be discussed further in the next section.

Anderson et al. (2004) matched a violent and non-violent video game on physiological arousal (heart rate), enjoyment, action,

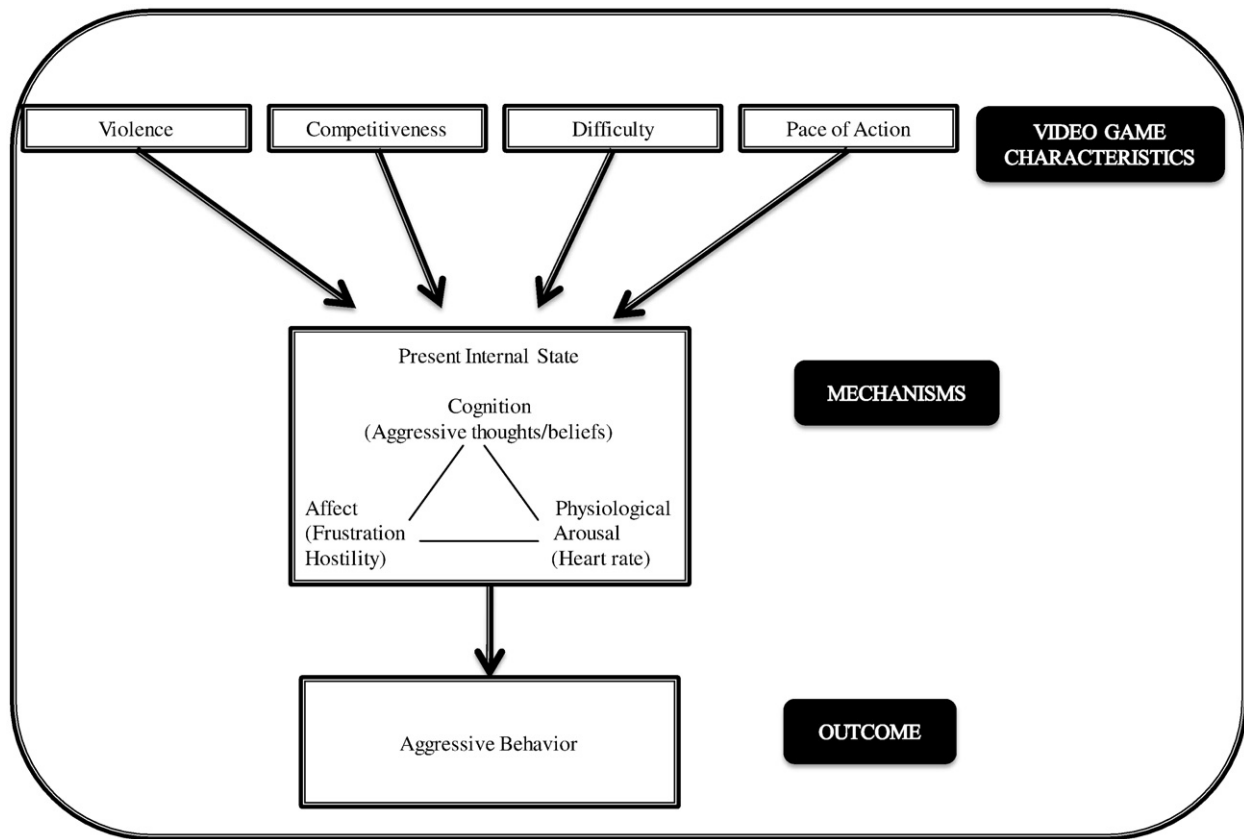


Fig. 2. A model of how video game characteristics might influence aggressive behavior in the short-term.

difficulty, and frustration, but failed to equate the games on competitiveness and pace of action. Similar to Anderson and Dill (2000), the violent video game, *Marathon 2*, and the non-violent video game, *Glider Pro*, were quite different in terms of competitiveness. *Marathon 2*, like *Wolfenstein 3D*, is a first-person shooter in which the main character has to compete in battle against many alien creatures in order to complete the levels and succeed in the game. On the contrary, in *Glider Pro*, the player attempts to navigate a paper airplane through a series of obstacles throughout a house with the aid of air currents from floor or ceiling ventilation ducts. Hence, *Marathon 2* involves more competition than *Glider Pro*. Also, the pace of action may have been higher for *Marathon 2*; however, the fact that physiological arousal level was equated between both games makes it unlikely that pace of action influenced aggressive behavior. Consequently, although Anderson et al. found that participants who played *Marathon 2* delivered significantly more intense punishments in a modified version of the TCRTT than those who played *Glider Pro*, it is unclear whether this result was due to the violent content alone, or whether the competitiveness of *Marathon 2* influenced aggressive behavior.

Anderson and Carnagey (2009) were the first to equate a violent and non-violent video game on competitiveness. They used four sports video games, which included two baseball games and two football games. Of the two baseball games, one was rated as more violent than the other, and one of the football games was rated as more violent than the other football game. The two violent sports video games included unnecessary violence, such as the ability to make a base-runner punch a baseman so that he drops the ball. In contrast, the two non-violent sports games attempted to authentically represent the sport by replicating the actual rules. Although the games differed in terms of violence, the violent sports video games did not differ from the non-violent games in ratings of competitiveness. The violent sports video games, however, were rated as more difficult than

the non-violent games. Consistent with the notion that game difficulty may influence frustration, the violent sports video games were also rated as more frustrating than the non-violent games. Furthermore, pace of action was also rated as higher for the violent games compared to the non-violent games. However, physiological arousal level did not differ between the violent and non-violent games, suggesting that the pace of action may not have had a large enough influence on physiological arousal to produce elevated levels after playing the violent games compared to the non-violent games.

In an attempt to control for the effect of difficulty and pace of action, Anderson and Carnagey included difficulty and pace of action (along with several other video game ratings) as covariates in the model. However, since the violent and non-violent video game differed on ratings of difficulty and pace of action, these variables should not have been used as covariates in an attempt to equate the two games. According to Miller and Chapman (2001), it is invalid to use analysis of covariance for preexisting groups (e.g. violent versus non-violent video game conditions) that do not vary randomly and that differ on the variables which are to be included as the covariates. For example, when the covariate is affected by the treatment (or in our case, the condition), removing the covariate may also remove part of the treatment effect or produce a spurious treatment effect, and thus the grouping variable will be altered in a way that often cannot be specified in a conceptually meaningful way (Miller & Chapman, 2001). Therefore, since difficulty and pace of action were rated higher for the violent video game compared to the non-violent video game, the two games cannot be equated by including difficulty and pace of action as covariates. Instead, a better option would have been to test for an interaction between difficulty and video game condition, and between pace of action and video game condition, to determine whether difficulty and pace of action predicted aggressive behavior for participants who played the violent video game but not for participants who played the non-violent video game. According to

Miller and Chapman, however, the only way to really examine whether the violent content would have produced elevated levels of aggressive behavior compared to the non-violent game would be to match the difficulty and pace of action between the games prior to the experiment. Consequently, although Anderson and Carnagey controlled for competitiveness and still found that the violent sports video games produced more aggressive behavior than the non-violent games in the modified TCRTT, it is unclear whether the violent content alone was responsible for the result. In order to examine whether the violence alone in violent video games produces elevated levels of aggressive behavior, future studies must first equate the violent and non-violent games on competitiveness, difficulty, and pace of action. In addition, there are several problems with the measure of aggressive behavior used in the studies conducted by Anderson and Dill (2000), Anderson et al. (2004), and Anderson and Carnagey, which will be described in the following section.

2.3. The measure of aggression

The most commonly used measure of aggressive behavior in the violent video game literature is the modified Taylor Competitive Reaction Time Test (TCRTT), in which the participant is told that he or she is competing with another participant (confederate) to see who can push a button faster upon the appearance of a cue (see Table 1). After each trial, the loser receives an aversive punishment (e.g., a loud noise blast) and the winner chooses the intensity of the punishment. The level of punishment intensity that the participant sets for his or her opponent and the duration of the punishment is indicative of aggressive behavior. Wins and losses are determined before the task begins, and the participant both receives and delivers punishments.

Table 1

Limitations with previous experiments examining the effect of violent versus non-violent video games on aggressive behavior.

Author and Date	Limitation(s)
Anderson and Dill (2000)	Games not equated on competitiveness. Used TCRTT.
Anderson and Carnagey (2009)	Games not equated on difficulty and pace of action. Used TCRTT.
Anderson and Murphy (2003)	Games not equated on competitiveness, difficulty, and pace of action. Used TCRTT.
Anderson et al. (2004)	Games not equated on competitiveness and pace of action. TCRTT.
Anderson et al. (2007)	Games not equated on competitiveness, difficulty, and pace of action. Used TCRTT.
Bartholow and Anderson (2002)	Games not equated on competitiveness, difficulty, and pace of action. Used TCRTT.
Bartholow, Sestir, and Davis (2005)	Games not equated on competitiveness, difficulty, and pace of action. Used TCRTT.
Barlett et al. (2009)	Games not equated on competitiveness and difficulty.
Cooper and Mackie (1986)	Games not equated on competitiveness, difficulty, and pace of action.
Carnagey and Anderson (2005)	Games not equated on competitiveness and difficulty. Used TCRTT.
Ferguson, Rueda, et al. (2008)	Games not equated on competitiveness, difficulty, and pace of action. Used TCRTT.
Graybill, Strawniak, Hunter, and O'Leary (1987)	Games not equated on competitiveness and pace of action.
Irwin and Gross (1995)	Games not equated on competitiveness, difficulty, and pace of action.
Konijn, Bijvank, and Bushman (2007)	Games not equated on competitiveness, difficulty, and pace of action. Used TCRTT.
Polman, Orobio de Castro, and van Aiken (2008)	Games not equated on competitiveness, difficulty, and pace of action.
Schutte, Malouff, Post-Gorden, and Rodasta (1988)	Games not equated on competitiveness, difficulty, and pace of action.
Silvern and Williamson (1987)	Did not include a non-violent video game condition.
Winkel, Novak, and Hopson (1987)	Games not equated on competitiveness, difficulty, and pace of action.

The first problem with the modified TCRTT is that the participant's motivation to behave aggressively is ambiguous. According to Lieberman, Soloman, Greenberg, and McGregor (1999), it is unclear whether participants view their behavior as competitive instead of aggressive, in that participants' motivation to give intense punishments may be to slow their opponents' response time on subsequent trials, thus allowing participants to win the competition. Recall that aggression refers to behavior that is intended to harm another individual. If the main intent for participants to deliver intense punishments to their opponents is to gain an advantage in the competition, instead of to actually cause harm to their opponents, then the TCRTT would actually be measuring competitiveness rather than aggression. Furthermore, participants may not even consider the fact that they could be causing harm to their opponents, depending on how immersed they become within the competition.

Why then, have participants who played violent video games been shown to select higher levels of punishment for their opponents than participants who played non-violent video games? The fact that the modified TCRTT may measure competitiveness instead of aggression is especially problematic when used in violent video game studies, as the majority of violent video games involve competition. For instance, the goal of violent video games tends to range from trying to shoot or stab opponent characters (e.g., first-person shooter games such as the *Call of Duty* series or action games such as the *Grand Theft Auto* series) to competing against opponents in a physical battle (e.g., fighting games such as the *Mortal Kombat* series or sports games such as the *Fight Night* series). Although some non-violent video games involve competition, such as racing games (e.g., the *Gran Turismo* series), many non-violent video games do not (e.g., *The Sim City* series, the *Myst* series, *Tetris*, and *Solitaire*). Consequently, violent video games may prime competitive schemas more than non-violent video games. Thus, when participating in the TCRTT after playing a violent video game, the competitive aspect of the task may become especially salient. A prime example is the aforementioned study by Anderson and Dill (2000). Clearly, *Wolfenstein 3D* involved much greater competition than *Myst*. Therefore, participants who played *Wolfenstein 3D* may have felt more competitive and administered longer punishment durations in order to hinder their opponents' performance in the TCRTT, compared to participants who played *Myst*.

Anderson and Carnagey (2009) examined why participants chose different punishment intensities for their opponents during the modified TCRTT with a questionnaire. Instrumental motivation, which is consistent with competitiveness (e.g., "I wanted to control my opponent's level of responses"), and revenge motivation (e.g., "I wanted to pay back my opponent for the noise levels (s)he set") was measured using 12 items. They found that both instrumental and revenge motivation predicted the average intensity of punishments delivered. Thus, it is evident that some participants view their behavior during the modified TCRTT as competitive rather than aggressive. For high intensity punishments (levels 8–10 on a 10-point scale), only revenge motivation was a significant predictor. However, although revenge motivation appears to measure aggression, it still may not tap into participants' desire to intentionally harm their opponent. For instance, the item "I wanted to pay back my opponent for the noise level (s)he set" may represent participants' desire for retribution in a competitive sense. In other words, because the modified TCRTT is a competitive task, the revenge motivation may be a product of the competition. In order to investigate whether violent video games directly influence aggressive behavior, future studies must unambiguously assess aggressive behavior by removing the competitive element.

The second problem is that aggression had not been measured in a uniform way in studies using the modified TCRTT to examine the relation between violent video games and aggression (Ferguson, Smith, Miller-Stratton, Fritz, & Heinrich, 2008). For example, Ferguson, Smith, et al. (2008) described seven different ways in which the TCRTT can be used to measure aggression, such as reporting

on the average intensity of punishment selected across all trials versus the average duration of punishment selected across all trials, reporting either average intensity or average duration after either “win” trials only or “loss” trials only, or using some arbitrary cutoff point (such as intensity scores of at least 7 on a 10-point scale). As previously described, Anderson and Dill (2000) found that participants who played a violent video game gave significantly longer durations of punishment than participants who played a non-violent video game after loss trials only. In contrast, Anderson et al. (2004) operationalized aggressive behavior as the intensity of the punishments selected, on a 10-point scale.

The third problem with the modified TCRTT is that consistent with Ferguson, Smith, et al.'s (2008) findings, it has been shown to lack validity as a measure of aggressive behavior. Ferguson and Rueda (2009) examined the convergent validity of the modified TRCTT with measures of trait aggression, domestic violence, and violent criminal acts. The results indicated that both intensity and duration of the modified TCRTT were not related to trait aggression, domestic violence, or violent criminal acts. To assess whether gender moderated the relation between the modified TCRTT and the three outcome measures, separate analysis were run for males and females. Although aggression and violence are more common among males, their scores on the modified TCRTT were not related to any of the three violent outcome measures. For females, scores on the modified TCRTT were only related to domestic physical violence. Therefore, Ferguson and Rueda concluded that the modified TCRTT does not appear to measure direct aggression.

In order to assess direct and unambiguous aggressive behavior, Lieberman et al. (1999) created the Hot Sauce Paradigm. As previously described, the Hot Sauce Paradigm involves informing participants that they are to create a hot sauce for a confederate to eat, who does not like hot or spicy food. The level of hotness and the amount of sauce given is indicative of aggressive behavior. There are no competitive benefits gained from administering a hotter sauce to the confederate, so the hot-sauce paradigm unambiguously assesses aggressive behavior with the intent to cause harm to another individual. Furthermore, Lieberman et al. found that scores on this paradigm were positively related to both trait and physical aggression scores on the Buss and Perry (1992) Aggression Questionnaire, supporting the convergent validity of the Hot Sauce Paradigm as a measure of aggressive behavior.

3. Conclusions: the importance of addressing the limitations

To date, no study has equated the violent and non-violent video games on competitiveness, difficulty, and pace of action (see Table 1). In addition, only one study has used an unambiguous measure of aggressive behavior (Barlett et al., 2009), but the violent and non-violent games were not equated on game characteristics. Thus, future research must examine whether a violent video game produces greater levels of aggression than a non-violent video game using an unambiguous measure of aggressive behavior (the Hot Sauce Paradigm), when both games are equated on competitiveness, difficulty, and pace of action. Instead of simply choosing video games that appear to differ in the level of violence but are equal in terms of competitiveness, difficulty and pace of action, participant ratings of these video game characteristics on a continuum are necessary. For example, when using a dichotomous violent versus non-violent scale, a video game such as Super Mario in which the main character must jump on other characters in the game in order to defeat them, may be labeled as a violent video game. However, due to the unrealistic and tame nature of Super Mario, ratings of violence would likely be significantly lower compared to a game with more realistic and graphic violence, when evaluated on a continuous scale.

Addressing these limitations has important implications for video game players. First, if a violent and a non-violent video game produce equivalent levels of aggression when they are matched on competi-

tiveness, difficulty and pace of action, then the level of violence in video games may be less influential in promoting aggression than previously believed. Furthermore, this finding would suggest that competitiveness, difficulty and pace of action may have had a larger than expected influence on aggression in previous studies that failed to match the violent and non-violent games on these game characteristics. For example, Barlett et al.'s (2009) finding that the violent video game produced more aggressive behavior than the non-violent video game may be due solely to the fact that the violent game was more competitive and difficult than the non-violent game. In addition, it may be incorrect to assume that all non-violent video games are unrelated to aggression simply because they lack violent content. Instead, it may be that decisions about whether non-violent games influence aggression should be made on a case-by-case basis, based on the degree to which the particular game is competitive, difficult, and fast-paced. In fact, a non-violent video game that is very competitive, difficult, and fast-paced may lead to more aggressive behavior than a violent video game that is rated lower on these video game characteristics. Future research could then investigate the relative influence of each of these individual video game characteristics on aggressive behavior to determine which characteristics have the greatest impact.

On the other hand, if a violent video game produces more aggression than a non-violent game that is matched on competitiveness, difficulty, and pace of action, it could be concluded with greater confidence than in past studies (i.e., where the games were not matched) that violent video games produce more aggression than non-violent video games because they have greater levels of violent content. Future research could then investigate whether violent video games that are more competitive, difficult and fast-paced lead to more aggressive behavior than violent video games that are rated lower in these game characteristics. Indeed, it may be that there are several video game characteristics that influence aggressive behavior.

Of course, there is always a tradeoff between experimental research and real-world generalizations. The fact that a participant in a lab setting may administer more of a hotter sauce to a confederate after playing a violent video game compared to a non-violent video game does not necessarily mean that people who play violent video games will have physical altercations outside of the lab immediately after playing the game. If this were the case, the rate of day-to-day violence and physical aggression would have dramatically increased in North America due to the recent rise in prevalence rates of violent video game play. However, such findings in controlled laboratory settings do suggest that violent video game play may increase the chance of an individual behaving aggressively if the opportunity arose shortly after exposure to the game. To further investigate the generalizability of this laboratory research to real-life aggression, future research should examine whether the Hot Sauce Paradigm correlates with measures of domestic violence and violent criminal acts, as Ferguson and Rueda (2009) did with the TCRTT. Furthermore, select populations such as people with aggressive tendencies may be more susceptible than the average person to the effects of violent video games on aggressive behavior. Thus, future research should examine the effects of violent video games on highly aggressive samples and compare these findings to the average population.

Research that examines the role of violent video games in producing aggressive behavior and addresses the limitations outlined in this review is critical. As Barlett et al. (2009) have shown, playing a violent video game for 15 min can produce elevated levels of aggressive behavior that lasts between 5 and 10 min. Therefore, the fact that many adolescents play violent video games for several hours every day clearly stresses the need for a greater understanding of the effects of violent video games on aggression. It is not until game characteristics are held constant and an unambiguous measure of aggressive behavior is used that the influence of violent content on aggression can be assessed.

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