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Examining the effects of video games from a psychological perspective: Focus on violent games and a new synthesis

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Examining the effects of video games from a psychological perspective:
Focus on violent games and a new synthesis

During the late 19th century and throughout the 20th century, new types of mass media were produced and consumed. Among others, these included dime novels, films, comic books, radio, recorded music, television, video games, and the Internet. Each new medium was often immediately praised for its potential benefits and reviled for its potential harms. For example, in the 1880s, dime novels were claimed to have a "demoralizing influence upon the young mind," resulting in courtrooms being "thronged with infant criminals—with baby felons" (West, 1988, 12-13). Although opinions like these are quick to surface, and often get great attention from the press, there are almost as many opinions as there are people who express them. How should one know which opinions are credible? Science can help to provide the answer, by providing empirically testable theories and facts about predictable patterns of behavior or opinion. This paper has three goals: (1) to describe how scientific psychological research can be (and is) conducted on the effects of video games, (2) to review the literature on the multiple effects of video games, with an emphasis on violent games (because they have been the most controversial and are also the most studied types of games), and (3) to provide a new synthesis describing four dimensions along which video games may have important effects.

Video and computer games, like earlier media, were immediately lauded as potential educational boons, and a great effort was launched to put computers into every classroom in America in the 1980s. This drive gained great momentum, despite a paucity of evidence that computers were more effective than (or even as effective as) more traditional educational techniques. Simultaneously, United States Surgeon General Koop released a statement about the dangers of video games (1982); this warning garnered attention despite a lack of scientific evidence for it at the time. The one benefit of these types of claims is that they provided an impetus for scientists to begin studying the effects of video games (in this review, I define "video games" to include console, computer, and arcade-based games). At the point of this writing, scores of studies have been conducted on the various effects video games may have. Unfortunately, there is still confusion about how scientific psychological research is conducted, how to interpret it, and how strong it is.

The Role of Theory in Psychological Research

Scientific psychology has a long history of conducting media effects research, and a longer history of conducting research on the effects of other stimuli on thoughts, feelings, and behaviors. However, individual studies by themselves (and even groups of studies) can tell us almost nothing without being grounded in a theory. The importance of theory cannot be underestimated in psychological research. Although an individual study can provide facts about a relationship between causes and effects, observed patterns of behavior cannot be fully understood in the absence of a theoretical framework. For example, a study might demonstrate that children who played a violent video game are more physically aggressive after playing than are similar children who played a non-violent game. By itself, this finding is provocative, but tells us little. Why did this occur? Is it a short-term or long-term effect? Was it a result of the violence in the game, or of some other factor (such as frustration)? If it was the violence in the game that caused the aggressive pattern of behavior, what is the mechanism by which the game ultimately affects behaviors? That is, did the game increase overall arousal, or aggressive emotions, or aggressive thoughts, or some other factor?

In psychology, no single study, taken alone, is ever considered to be definitive. In the present example, a researcher might go on to propose a theory that explained how and why violent game play ultimately results in observable behavior differences (for example, by priming aggressive thoughts). Additional studies would then be conducted to investigate whether violent games actually do prime aggressive thoughts, and whether these thoughts “cause” the observed increases in aggressive behaviors.

This is precisely how theories are so useful. They allow the formation of specific predictions, and those predictions are empirically testable. If further studies reveal that violent games prime thoughts, but that those thoughts don’t completely explain patterns of aggressive behaviors, then the theory must be revised and tested again. This process allows for a rich and detailed theory to be constructed based on empirically-derived facts, rather than on opinions. ”Exploratory” or atheoretical studies can be useful for discovering novel phenomena or beginning a program of research. But by themselves, studies divorced from empirically-testable theories are of little use because they have no context within which they can be understood.

The literature on video games has, to this point, lacked a broad theory within which to interpret the many and varied types of results that have been found. This has often allowed the dialogue over the effects of video games to be reduced to a question of whether video games are “good” or “bad.” However, within specific domains, some very good theories have been described and tested. I will describe briefly one of these domain-specific theories, the General Aggression Model, and review some of the literature on violent video games. It is important to note that, although this model has received considerable empirical support, it cannot explain many other findings in the literature, such as why video games might improve visual attention (e.g., Green & Bavelier, 2003), increase obesity (e.g., Vandewater, Shim, & Caplovitz, 2004), lower school performance (e.g., Gentile, Lynch, Linder, & Walsh, 2004), or improve surgeons’ advanced laparoscopic surgical skills (Rosser et al., 2004).

The General Aggression Model

The General Aggression Model is designed to predict both the short-term likelihood of an individual engaging in an aggressive behavior, and also the long-term changes that increase the likelihood of future aggressive behavior (see Anderson & Carnagey, 2004; Anderson, Gentile, & Buckley, under contract; Anderson & Huesmann, 2003 for detailed descriptions). Figure 1 displays the basic short-term, or episodic, component of the model. In any given potentially aggressive social encounter, there are both proximal and distal influences. The distal influences include biological and environmental modifiers, which together influence aspects of people's personalities. A person's personality includes many measurable dimensions (e.g., hostility) that can increase or decrease the likelihood of aggression, and personality also influences the types of situations that the individual is likely to encounter. Once in a given social situation (proximal influence), aspects of both the person and the specifics of the situation combine to affect the present internal state of the individual.

Under the parameters of the General Aggression Model, it is theorized that three aspects of internal state can be affected (and are relevant for aggressive action): the current thoughts the individual has (cognition), their feelings (affect), and their level of physiological arousal. Assuming that person A has just been insulted by person B (a situational variable), person A will likely have increased arousal (heart rate, blood pressure, stress hormones), increased negative feelings, and perhaps increased aggressive thoughts. Before person A reacts behaviorally, however, he/she goes through an appraisal and decision process. These processes include immediate perceptions/reactions, and if person A does not have sufficient cognitive resources to explicitly consider them, he/she will react immediately and impulsively. Even if there are opportunities to consider the potential reactions, if the initial response is considered satisfactory or the potential consequences are not important, the impetuous action can occur immediately. If the initial response is not satisfactory or the consequences might be important, then they can be reappraised until a satisfactory response is decided upon, and the reaction will follow this delay. This action changes the social encounter, characteristics of which, in turn, affect person and situation variables, and the cycle continues.

This theory allows for a variety of specific hypotheses to be advanced and tested. For example, it predicts that playing a violent video game (situational variable) might increase aggressive thoughts, which in turn may increase automatic aggressive behaviors. This hypothesis has been tested, and support has been found for it (e.g., Anderson, Carnagey, Flanagan, Benjamin, Eubanks, & Valentine, 2004; Anderson, Gentile, & Buckley, under contract).

The long-term aspects of the theory are shown in Figure 2, which displays many of the personality variables believed to be influenced by an individual's ongoing bio-social interactions. What is learned across time depends on the experiences an individual has, including interactions of experiences with biological factors (such as biological predispositions to learn certain types of associations through rewards and punishments). Violent video games may affect individuals over time by influencing their aggressive beliefs, schemata, and scripts, and by desensitizing them to aggression. As children begin to see the world in aggressive terms and therefore begin to act more aggressively, their personalities change to become more aggressive and hostile. These changes will likely result in increased opportunities for aggressive behavior, because of both changes in the individual's personality variables and changes in the situations the individual is likely to encounter as others react to the individual. Thus these experiences and changes over time act as distal processes and causes of later aggressive encounters (Figure 1).

Psychologists consider theory testing to be critical to evaluating research evidence. It is not sufficient for studies to show some relation between video games and behavior. We must be able to predict the relation, and explain why that relation exists. Every part (every box and arrow in Figures 1 and 2) of the theory should be testable, and the theory must be revised as needed. This process is crucial because no single study is ever conclusive. Each study has particular strengths and weaknesses, and the goal of science is to test theories with many types of studies, and keep refining the theories until it is possible to explain not only what happens, but why it happens.

Types of Study Designs

In general, there are three dominant types of study designs, and each has distinct strengths and weaknesses. They are experimental, cross-sectional (or correlational), and longitudinal.[1]

Experimental Studies

The major strength of experimental studies is that causality can be determined. This is done by randomly assigning participants to different groups, and treating each group identically except for one variable (the "independent variable"). If the groups are shown to differ in some measurable way (the "dependent variable") at the end of the study, the most probable explanation is that the independent variable caused the changes in the dependent variable. As Anderson and his colleagues have argued (e.g., Anderson et al., under contract; Gentile & Anderson, in press), in the case of experimental studies of violent video games, at least four

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[1] There are several taxonomies under which one could classify the different types of research designs. The three types discussed here are not exhaustive, but are the most typical and comprise the vast majority of media effects studies.

characteristics serve as markers of high quality studies: adequate sample size (at least 200)[2]; violent and nonviolent games equated on potentially confounding dimensions (e.g., difficulty or frustration levels); violent and nonviolent games that are truly violent and nonviolent (respectively); and a clear and valid measure of aggression or aggression-related variables assessed for the game-playing participant. Over 30 independent experimental tests have been conducted on the short-term effects of violent video games, yet few of them share all of these features.

Table 1 displays the major results of experimental studies of video games on aggressive affect (emotions), physiological arousal, aggressive cognitions, and aggressive behaviors. Many have samples of fewer than 200 participants. Small samples make it much less likely that researchers will find a significant difference, even where one really does exist. For example, Funk, Buchman, Jenks, & Bechtoldt (2003) found no immediate effect of violent game play on aggressive cognitions, but they reported that the observed power they have to find a significant difference with a sample size of 66 is very small: $1-\beta = .10$.[4] Other studies may be criticized because they present no evidence that the violent and nonviolent games are equated on difficulty or other potentially confounded dimensions. Many did not match violent and non-violent games on other confounding dimensions, such as frustration or fun, and others had no control game (e.g., Calvert & Tan, 1994;Graybill, Kirsh, & Esselman, 1985; Irwin & Gross, 1995; Lightdale & Prentice, 1994; Scott, 1995; Wingrove & Bond, 1998). Furthermore, some studies included games that either were not really violent or included abstract violence against space ships rather

[2] A sample size of 200 is needed to have sufficient power to detect effect of the size typically found in this literature (Anderson & Bushman, 2001).

[4] Power ($1-\beta$) is defined as the odds of finding a statistically significant effect when one truly exists. This reported power can be interpreted as meaning that only 10 out of 100 studies with a sample size of 66 could find an effect – not good odds. Increasing the sample size makes it much more likely that an effect, if there is one, will be found.

than violence against human figures (e.g., Anderson & Ford, 1986; Cooper & Mackie, 1986; Hind, 1995; Winkel, Novak, & Hopson, 1987). Other studies reported measures that are only tentatively related to aggression or relied on how "aggressively" participants played the game as the measure of aggression (e.g., Ballard & Panee, 2001; Graybill et al., 1987; Hind, 1995; Lightdale & Prentice, 1994; Van Schie & Wiegman, 1997). Still other studies have used aggressive trait measures or self-reports of past aggression as the dependent measure of aggressive behavior (e.g., Ballard & Wiest, 1996; Scott, 1995). Unfortunately, this is not a complete list of methodological flaws found in this domain. For example, Graybill et al. (1987) title their study "Effects of playing versus observing violent versus nonviolent video games on children's aggression," but combined players and observers in their analyses. The first experiment to include all four aspects of a high quality study was reported in 2000 (Anderson & Dill).

Yet despite the various methodological flaws of individual studies, the vast majority still document an increase in aggressive feelings, arousal, cognitions, and behaviors as a result of violent video game play (as shown in Table 1). Because these are experimental studies, we are able to conclude that violent games can *cause* increases in aggressive thoughts, feelings, and behaviors. Most of these studies document only short-term effects (what happens immediately post-play), although it is possible to design experimental studies to measure longer-term effects.

The major weakness of experimental studies is that researchers often rely on artificial ways of testing what they wish to investigate. For example, it is unethical to allow participants to hit each other as a measure of aggressive behavior. Thus, researchers use other means such as the noise-blast paradigm (e.g., Anderson & Dill, 2000; Anderson et al., 2004; Persky & Blascovich, 2004). It is then incumbent upon researchers to demonstrate that their laboratory measures have real-world validity. With the noise-blast paradigm, specifically, several studies have shown that people who give higher blasts in the laboratory are also more likely to physically aggress in the real world (e.g., Anderson & Bushman, 1997; Bernstein, Richardson, & Hammock, 1987; Carlson, Marcus-Newhall, & Miller, 1989; Giancola & Zeichner, 1995).

Cross-Sectional Studies

Cross-sectional studies allow researchers to overcome the primary weakness of experimental studies because they can use a wide range of "real world" measures of aggression. Thus, researchers can study the relations between violent game exposure and several types and severities of aggression. Cross-sectional studies can also incorporate multiple informants (e.g., self, peers, parents, teachers), thereby gaining additional levels of ecological validity. High quality cross-sectional studies share several important characteristics: adequate sample size (at least 200); a reliable measure of exposure to violent video games; and a reliable measure of aggression or of an aggression-related variable (Anderson et al., under contract; Gentile & Anderson, in press). The first published cross-sectional studies with all three of these characteristics appeared in 2000 (Anderson & Dill, 2000; Colwell & Payne, 2000).

Table 2 displays the major results of a number of cross-sectional studies of video games on aggressive affect, physiological arousal, aggressive cognitions, and aggressive behaviors. Again, many have small samples. Many did not measure violence exposure, but only measured total amount of video game play or amount of play of certain categories of games (e.g., Dominick, 1984; Farrar & Krcmar, under review; Fling et al., 1992; Lin & Lepper, 1987; McClure & Mears, 1986). Several use questionable approaches to measuring aggression (e.g., McClure & Mears, 1986; Wingrove & Bond, 1998). Again, this is not a complete catalogue of methodological flaws, and despite them, the vast majority of these studies still document an increase in aggressive feelings, arousal, cognitions, and behaviors (as shown in Table 2).

Because these are cross-sectional studies, we are able to conclude that violent games can be related to serious aggression, such as aggressive delinquency and physical fights. Furthermore, these relations are likely to be long-term relations rather than short-term relations. The major weakness of cross-sectional studies is that causality cannot be determined. However, correlational studies are important in that they *can* support, refine, or refute causal theories. More importantly, cross-sectional studies are strong where experimental studies are weak, and experimental studies are strong where cross-sectional studies are weak.

Longitudinal Studies

Longitudinal studies allow researchers to overcome some of the weaknesses of both experimental and cross-sectional studies. In a longitudinal study, researchers study the same people over a period of time. They can thus observe patterns of behavior and document both short-term and long-term effects. Longitudinal studies can be either experimental or cross-sectional in design, but even cross-sectional designs can provide some causal information, as it is possible to determine what precedes what over time. The best longitudinal studies should share the same characteristics of high quality experimental and cross-sectional studies.

To date, only four longitudinal studies of video game violence and aggression have been conducted (Table 3). In one, 41 adolescents played either a hand-to-hand fighting game (Mortal Kombat), a violent horror game (Resident Evil), or a sports game (NBA Live) once a week for three weeks (Ballard, Panee, Engold, & Hamby, 2001). Physiological arousal (heart rate & blood pressure) and emotions (facial smiling and disgust displays) were measured during play, and self-reported anger, frustration, arousal, and relaxation were measured post-play. Heart rate, blood pressure, and facial displays of disgust decreased significantly over the three play periods, showing desensitization with repeated exposure. Self-reported variables did not change significantly, and there were no reported differences in desensitization by game type. However, this study included a very small sample (only 13-14 playing each game), and only one hour of play each week for three weeks.

In the second longitudinal study, 807 Japanese 5th and 6th graders were surveyed twice during a school year (Ihori, Sakamoto, Kobayashi, & Kimura, 2003). The experimenters found that the amount of video game play at Time 1 was significantly (but weakly, $r = .08$) related to later physical aggression, but aggression at Time 1 was not related to later video game play. However, the authors only measured the *amount* of video game play, and did not report whether the children were playing violent games. This distinction between the amount and content of the games is theoretically and empirically important, and will be discussed in greater detail later.

In the third study, 2,550 6th and 7th grade students were surveyed four times over two years about their violent media consumption (action movies, video/computer games involving weapons, and Internet sites describing/recommending violence), and their attitudes about and engagement in aggressive behaviors (Slater, Henry, Swaim, & Anderson, 2003). The strength of this approach is that it allows for a strong test of the mutual reinforcement hypothesis (i.e., that aggressive kids seek out violent media, which in turn make them more aggressive, which makes them seek out more violent media, which further increases their aggressive tendencies, etc.). Indeed, this downward spiral is exactly the pattern that was found. However, this study also has several problems – the most relevant here is that no data were reported for violent video games independently, so it is impossible to determine the effect of violent games by themselves.

However, the results are likely to be underestimates of the effects, because the measures used were not sensitive measures of media violence exposure.

In the fourth longitudinal study, 213 gamers were recruited to play a massively multiplayer online role playing game (MMORPG), 75 of whom were given the game which included violent content (Williams & Skoric, 2005). Most of the gamers were adults (mean age = 28, range 14-68). The experimental group were requested to play the game for at least 5 hours per week for four weeks, although one third (32%) did not. At the beginning and end of the month, all participants were given a normative beliefs about aggression survey, and were asked to report whether they had been involved in a "serious argument" with a friend or a partner during the previous month. There was no relation between game play and change in normative beliefs in aggression. There were significant correlations between game play and both arguments with friends and partners, but not with changes in arguments from time 1 to time 2. Unfortunately, this study suffers from several critical flaws. The most important flaw is that the researchers included no true measure of aggression. Arguments with friends and partners are sometimes antisocial behavior, but are rarely aggression. When they are aggression, they are typically characterized by verbal aggression. Violent video games typically model physical aggression, not verbal aggression. Therefore, we would not expect them to have much effect on verbal aggression. Furthermore, by only asking participants to self-report whether or not they had been involved in arguments (yes/no), there was no way for this study to measure increases in antisocial behaviors. If one had been involved in an argument at the beginning of the study and also at the end, this study would have only been able to show no change.

However, there are many other flaws with this study. The study failed to find changes in normative beliefs about aggression. However, these types of beliefs are trait-like – that is, they would only be expected to change over a long period of time, not within one month. It is true that the measure used has been used in short-term experimental studies successfully, but in these cases it is theorized that the effect is due to cognitive priming, rather than making long-term changes in personal beliefs. Because the participants did not complete the survey immediately after playing the violent game, we would not expect to see any effects on this measure. Therefore, the failure to find an effect here is consistent with psychological theory and does not suggest that violent games have no effect on beliefs.

The experimental and control groups were not treated equally, which is paramount for being able to compare the groups at the end of the study. This resulted in differential attrition rates (16% of the experimental group dropped out, compared to 51% of the control group). Perhaps even more importantly, the researchers did not measure what games the control group played during that month. It may be that they exceeded the experimental group in overall violent video game exposure, although not by playing the particular experimental game.

Finally, there are significant questions yet to be answered about whether MMORPGs would have the same effects as more traditional video games, even those in which one plays against other gamers. They are far more social, and involve more non-violent strategy, socializing, and prosocial cooperative behavior than typical violent first-person shooter games. These types of games have not been shown previously to affect aggression in the short-term or the long-term, so it is unclear why the authors expected to find an effect on antisocial behavior.[5]

In the fifth longitudinal study, 430 3rd, 4th, and 5th graders, their teachers, and their peers were surveyed at two points during the school year (Anderson et al., under contract; Study 3). Students who played more violent video games began to see the world in more aggressive ways

[5] It appears from examining the dissertation on which the published manuscript was based that the study was also supported substantially by the video game publisher (providing 75 free copies of the game and a month of free access for the study participants), although this potential conflict of interest is never stated.

(i.e., they had an increase in hostile attribution bias). Research has shown that children who exhibit this cognitive bias (to assume that negative things happen due to hostile intent rather than by accident) are far more likely to react aggressively (Bensley & Eenwyk, 2001; Crick, 1995; 1996; Crick & Dodge, 1994). Indeed, children who had high exposure to violent video games changed over the school year to become more verbally aggressive, more physically aggressive, and less prosocial (as rated by their peers and teachers; raw *r*s ranged between .24 and .40). It appears that not only does repeated exposure to violent video games increase aggressive behavior, but it also decreases empathic helpful behavior. This may be especially important because increased aggressive behaviors and decreased prosocial behaviors also predicted peer rejection (Anderson et al., under contract). This study has several strengths over the preceding longitudinal studies, including more sensitive violence exposure measures and the use of multiple informants. However, the lag time between the two surveys was relatively short, ranging between two and six months.

Again, even with the different strengths and weaknesses of these studies, they also document increases in aggressive cognitions and behaviors in connection with media violence exposure (Table 3). Because these are longitudinal studies, we can make some claims about a likely causal direction, as later behaviors cannot cause prior behaviors. However, unless the studies are experimental in design, strong causal claims cannot be made.

Psychologists rarely put much weight on any single study, because each type of study has distinct strengths and weaknesses. Ultimately, what psychologists look for is convergence in the results of different studies using different methods and varied measures. If experimental, cross-sectional, and longitudinal studies all point to the same conclusion, then the results become very convincing.

Meta-Analyses

There is yet one more tool scientific psychologists use to help draw general conclusions – meta-analysis. This is a statistical technique, in which the data from many types of studies are collected and analyzed together. This allows for conclusions to be reached that are not dependent on any single methodology, population, or type of measurement. It also solves a problem that is inherent in narrative reviews. Most narrative reviews only report published studies. However, it is likely that some studies do not get published because the researchers found no effect, and many journals have a bias against reporting studies with null results[6]. Meta-analyses collect as many published and unpublished studies as can be found. Therefore, they are an excellent test of whether an effect is "real" and how strong the effect is. (For an excellent review of meta-analytic techniques related to media violence, see Comstock & Scharrer, 2003.)

Several meta-analyses have been conducted on violent video games (e.g., Anderson, 2004; Anderson & Bushman, 2001; Anderson, Carnagey, Flanagan, Benjamin, Eubanks, & Valentine, 2004; Gentile & Anderson, 2003; Sherry, 2001). All of them have concluded that there is a significant relation between violent video game play and aggression. Anderson and his colleagues have conducted detailed analyses on five specific effects (e.g., Anderson & Bushman, 2001; Anderson et al., 2004). Across studies, violent video games have significant effects on aggressive affect, physiological arousal, aggressive cognitions, and aggressive behaviors. They are also significantly negatively related to prosocial behaviors. These conclusions hold for both experimental and cross-sectional studies, so both causality and applicability to real-world aggression can be inferred (., 2004). These conclusions also hold for studies with children and adults (Gentile & Anderson, 2003). It would be expected that we might find larger effects with

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[6] This has sometimes been called the "file-drawer" problem, in that studies with null results are often relegated to one's file drawers.

newer studies since violent video games have become more violent over time. Indeed, this is the pattern found, with earlier studies showing smaller effect sizes than more recent studies (Gentile & Anderson, 2003). (However, this analysis is not entirely conclusive, because it may be that newer studies find larger effects just because researchers have become better at measuring them.) Finally, it could be argued that the pattern of effects is driven by methodologically flawed studies – that is, poorer quality studies show a large effect, but high-quality studies show small or no effects. Anderson et al. (2004) coded each of the studies included in the meta-analysis on nine different quality dimensions, and the opposite pattern was found. Methodologically weaker studies actually show significantly smaller effects of violent video games than do studies using "best practices."

Given the preponderance of evidence from all types of studies (experimental, cross-sectional, longitudinal, and meta-analytic), it seems reasonable to conclude that violent video games do indeed have an effect on aggression.

The Broader Context: Other Types of Video Game Effects

The preceding discussion is meant to describe how psychologists study the effects of video games empirically, and what evidence is necessary to draw conclusions from those studies. These methods have been used to document many other types of effects, some of which will be discussed here..

School Performance

Several studies have documented negative correlations between video game use and school performance for children, adolescents, and college students (e.g., Anderson & Dill, 2000; Anderson et al., under contract; Creasey & Myers, 1986; Gentile et al., 2004; Harris & Williams, 1985; Lieberman, Chaffee, & Roberts, 1988; Roberts, Foehr, Rideout, & Brodie, 1999; van Schie

& Wiegman, 1997; Walsh, 2000). In general, a preponderance of studies shows a consistent negative correlation between recreational video game play and school grades. Durkin and Barber (2002) recently attempted to argue that there is no negative relation between video game use and school grades (or many other variables). Specifically, they reported that students who never use computers have lower grades (mean GPA = 2.53) than low use (2.79) and high use (2.61) students (usage measured with a single 7-point Likert scale from "never" to "daily"). Yet, they based these conclusions on survey data gathered in 1988, before games became particularly violent, and when there was a strong relationship between computer use and socio-economic status. That is, children from poorer families were far less likely to own computers in 1988. Children from poorer families also typically have poorer school performance. Therefore, this is not a fair comparison. A better test is whether the low use and high use groups differ, since both groups come from families that own computers. Their data actually show that high use students have significantly lower GPAs than low use students.[7]

These data notwithstanding, there is reason to expect that some types of computer use may have positive effects on school performance. In one early study, Lieberman, Chafee, & Roberts (1988) showed that children who use computers to play games perform more poorly in school, whereas those who use computers for schoolwork perform better in school. Furthermore, the belief in the benefits of educational software and video games (known as discrete educational software) is so widespread that such software is second only to word processing software in its availability and use in school classrooms (Murphy, Penuel, Means, Korbak, & Whaley, 2001). Although the quality of research in this domain varies widely, meta-analyses of recent high quality studies of the efficacy of discrete educational software show an effect size of .38

[7] This confound completely changes the interpretation of their data, as it can explain why students who never use computers also have higher depressed mood, lower self-esteem, higher disobedience, substance use, and truancy, and lower GPAs than computer users. All of these relations would be predicted by lower SES.

(Murphy et al., 2001). That is, there is a significant correlation between student use of educational software and student achievement. The average correlation is .35 for educational games teaching reading skills, and .45 for games teaching math skills. The efficacy for teaching pre-reading skills may be even greater than for teaching reading skills. The average correlation between educational software/games and reading skills is .44 for pre-kindergarten and kindergarten children. These are large and potentially important effects, and show that video games can be powerful and effective teachers.

Physical and Mental Health

Several studies have examined relations between video game play and various aspects of physical health, although there has been no systematic attempt to organize or coordinate these types of studies. Video games have been shown to teach children healthy skills for the self-care of asthma and diabetes (Lieberman, 1997; 2001). These games have succeeded on multiple levels, modifying the attitudes, skills, and behaviors that they were designed to teach. Recent advances in virtual reality (VR) technology have also made it possible for physicians and therapists to incorporate them into therapeutic programs. For example, several studies have shown that VR programs can be effective in helping patients manage the pain of burns and wound care, as well as desensitizing phobic patients to their fears, such as fear of heights, flying, and spiders (Hoffman, 2004; Wiederhold & Wiederhold, 2005).

However, there are several studies documenting varied negative correlations between video games and physical health. The amount of time American children spend in front of electronic screens is considered by many to be an important environmental factor in the epidemic of childhood obesity. Obesity has been called the most common health problem facing children (Strauss & Knight, 1999), and its incidence has been increasing since the 1980s (Slyper, 1998).

Some research documents that the amount of time spent with video games can be linked to lower activity levels, higher weight, and higher risk of obesity (Berkey et al., 2000; Subrahmanyam et al., 2000; Vandewater, Shim, & Caplovitz, 2004).

A number of studies have documented video-induced epileptic seizures in some children and adults (Graf, Chatrian, Glass, & Knauss, 1994; Kasteleijn-Nolst Trenite et al., 1999; Badinand-Hubert et al., 1998). Research suggests that seizures can be activated by rapidly flashing images (Ricci et al., 1998), and that games vary significantly in their likelihood to activate seizures (Ricci & Vigevano, 1999). Although this is an unlikely occurrence for most people, other physical ailments are more likely given the increasing amount of time children are spending with video games. For example, there are a number of muscular and skeletal disorders associated with heavy computer or video game use, such as tendonitis and nerve compression. Indeed, there is even a form of tendonitis named “Nintendinitis,” caused by repeatedly pressing game-controller buttons with one’s thumb (Brasington, 1990).

Skill Development

For many children, video games are an introduction to computer and information technology. Playing games may afford a comfort level with computer interfaces and input/output devices. For example, this author’s daughter understood the computer mouse terms “point” and “click” by age three. Beyond this basic familiarity with technology, some researchers have argued that video games are the “training wheels” for computer literacy (e.g., Subrahmanyam, Kraut, Greenfield, & Gross, 2000). Computer literacy includes skills beyond traditional literacy skills, such as iconic (image representation and manipulation), spatial, and visual attention skills. There is evidence that each of these skills can be affected by video games.

In a study with 206 undergraduates in the US and Italy, playing a video game for 2 ½ hours (*Evolution* or a memory game similar to *Concentration*) improved students' ability to learn iconic information about electric circuits compared to no game or physical memory game control groups (Greenfield, Camaioni, Ercolani, Weiss, Lauber, & Perucchini, 1996). This is particularly interesting, because the diagrams of electric circuits were completely unrelated to the content of the video games played. Also, participants were more likely to answer questions about electric circuits using iconic (rather than verbal) representations if they had played the memory game on the computer rather than mechanically/physically.

Video games also have been shown to improve spatial skills. In one experimental study with 61 5th graders, students played either *Marble Madness*, a game requiring the spatial skills of guiding objects, judging speeds and distances, and intercepting objects, or *Conjecture*, a game with word puzzles (Subrahmanyan & Greenfield, 1996). Students given 2 ½ hours of experience with *Marble Madness* showed significant improvement in dynamic spatial skills (the change was most pronounced in those who started out with relatively poorer skills), whereas those given the same amount of experience with *Conjecture* did not improve. Okagaki & Frensch (1996) reported two studies of undergraduates given 6 hours of practice on *Tetris*, a game that requires spatial skills of mental rotation and spatial visualization. In the first, playing *Tetris* significantly improved spatial performance on a paper-and-pencil test for men but not for women (compared to a no video game control group). In the second, playing *Tetris* significantly improved spatial performance on mental rotation and spatial visualization on a computer-administered test for both men and women.

Greenfield, Brannon, & Lohr (1996) describe a cross-sectional study that suggests that playing games using two-dimensional (2D) representations of three-dimensional (3D) space may improve 2D-3D spatial skills. Skill playing *The Empire Strikes Back*, a game involving navigating through 3D spaces, was correlated with mental paper-folding visualization skills.

With regard to visual attention skills, a study with college students to determine relative ability to keep track of several different things on a computer screen at the same time (a skill similar to those needed by flight controllers) concluded that expert video game players were better at maintaining divided visual attention than were novices. In a second study, five hours of playing a video game led to increased response speed in the visual attention task, regardless of previous video game experience (Greenfield, deWinstanley, Kilpatrick, & Kaye, 1994). Other studies have documented relations between video game play and visual selective attention (Green & Bavelier, 2003), spatial visualization (Dorval & Pepin, 1986), mental rotation (De Lisi & Wolford, 2002), and reaction times (Griffith, Volschin, Gibb, & Bailey, 1983).

Video games can also provide opportunities for practice in the use of motor skills. In a study of college students, playing a golf video game improved students' actual control of force when putting, even though the video game gave no proprioceptive feedback on actual putting movement or force (Fery & Ponserre, 2001). There have even been studies with adults showing that experience with video games is related to better surgical skills (e.g., Rosser et al., 2004; Tsai & Heinrichs, 1994).

Dimensional Approach to Video Game Effects

As described above, there are several video game effects research methods, and a wide variety of effects have been documented. However, it has been difficult to understand this range of effects, because they do not seem to be just one type of effect. Following the reasoning of Gentile & Stone (in press), it is likely that there are at least four theoretically independent dimensions along which video games can have effects: amount, content, form, and mechanics.

Amount

Many of the effects noted above appear to be primarily due to the amount of time one spends with video games. These include the relations between video games and obesity, muscular and skeletal disorders, and school performance. In fact, there is evidence that amount has distinct effects independent of other types of effects. In path analyses with 607 8th and 9th graders, total amount of time playing video games directly predicted poorer grades, but was not directly related to antisocial or aggressive behaviors. However, playing *violent* games directly predicted aggressive behaviors, but did not predict poorer school performance (Gentile et al., 2004). Similarly, in the longitudinal study with 3rd through 5th graders, total amount directly predicted poorer grades, but was not directly related to aggressive or prosocial behaviors (Anderson et al, under contract). Conversely, playing violent games directly predicted increased aggressive behaviors and reduced prosocial behaviors (a *content* effect, as described below), but did not directly predict grades. These studies provide some evidence for the displacement hypothesis, which predicts that electronic media can influence learning by taking the place of other educational activities (Huston et al., 1992).

However, total amount may not be the only aspect of amount that matters – how children distribute their time with video games may also enhance or reduce the effectiveness of learning from them. Educational psychologists have shown that learning and transfer are most likely if the learner practices some each day (distributed practice) rather than "cramming" – trying to learn it all at once in one long session (massed practice). From an educational standpoint, video games encourage a close-to-optimal combination of massed and distributed practice. Initial attempts at the game provide immediate feedback and most people will keep playing until they begin to show some progress. Such massed practice eventually begins to produce diminishing returns (when a plateau is reached or fatigue sets in). However, the repetition will have begun to develop both physical and mental skills on parts of the task. Each subsequent encounter with the game provides memory benefits – namely, relearning anything that was forgotten, providing new cues for memory, interpreting new information or examples with what is already in memory, and reorganizing the memory accordingly. This combination of massed practice to build sufficient initial mastery to play the game, followed by distributed practice over days or weeks is optimal for learning (e.g., Ellis & Hunt, 1993; J. R. Anderson, 1983; Glaser, 1984). Although there is a great deal of research on this aspect of repetition and amount in traditional education, there is almost none with video games. In one study with middle school and college students, it was hypothesized that if students play violent games (but not non-violent games) repeatedly over long periods of time, then those students should show more aggressive cognitions and behaviors (Gentile & Gentile, under review). This pattern was found, as students who distributed practice over more days and years were more likely to evidence aggressive cognitions and behaviors, but only if they played violent games. Among students who played fewer violent games, there was no relation between distributed practice and aggressive variables.

Content

Most of the research on video games has documented what are likely to be effects of the content of the games. Specifically, research on violent video games, educational video games teaching reading or math skills, virtual reality programs helping to reduce phobias, and the asthma and diabetes health promotion video games all document effects of game content. In the case of educational games, these are intentional content effects; in the case of violent games, these are unintentional content effects. As described above, there is evidence that violent content has effects that are specific to aggressive and prosocial behaviors (Anderson et al., under contract; Gentile et al., 2004), and that these effects are theoretically and empirically independent of the effects of amount (although it should be noted that there is a significant correlation between amount and violence exposure – people who spend a lot of time playing video games also tend to be exposed to more violent content).

Form

There is a large body of literature with television and film on what are called "formal features." In general, this literature examines how people understand the formal conventions of the medium and what they signify. For example, most people extract different meanings from editing *cuts* and *dissolves*. If a couple goes through a door into a bedroom and the scene gradually dissolves to the next morning, most people take a very different meaning away from it than if the scene is simply (and abruptly) cut to the new scene the next morning. Similarly, several of the studies on video games suggest patterns of effects that are not due to the content *per se*, but to the form in which it is presented. Like the research on formal features in film and television, there appear to be many features that are capable of differential effects, only three of which will be discussed here.

First, some games require the use of 2D representations to provide 3D information and navigation (O'Keefe & Zehnder, 2005). If players play these types of games, then we should be able to document improvements in their ability to use 2D information for 3D navigation. Although data are limited at this point, two studies suggest that these skills may be learnable and show transfer. In the first of these, Greenfield et al. (1996) showed that skill in a game requiring 3D navigation was related to 3D mental visualization skill. Second, Rosser et al. (2004) showed that demonstrated skill on video games and past experience with video games were the best predictors of surgeons' advanced laparoscopic surgical skills (laparoscopic surgery is a minimally invasive set of procedures that include the insertion of a camera into the body; the surgeon then operates from outside the body by looking at a video screen to direct his/her motions). Surprisingly, video game experience and skill were better predictors of advanced surgical techniques than either amount of medical training or number of laparoscopic surgeries performed. These findings are difficult to explain using only *amount* or *content* types of explanations, but seem to fit a *form* argument - that more experience with games leads to increased skill in using 2D representations for 3D navigation.

Second, some games require constant scanning of the screen for information – for example, in action games it is critical to be constantly scanning all parts of the screen because an "enemy" could jump out from anywhere and a quick reaction is necessary. If players play these types of games, then we should be able to document improvements in visual attention skills to computer screens. This pattern has indeed been found, comparing different types of games that require different types of attention (Green & Bavelier, 2003; Greenfield et al., 1994).

Third, some games portray their subjects with more realism than others. If players play games with similar content, but with varied realism, then we should be able to document better learning and transfer. There are few data to support this at the present time, but it makes intuitive sense when considering simulation games. For example, if one wanted to learn to fly an airplane, more realistic simulators should result in better learning that would transfer to outside situations. Some results appear to suggest this may be correct, such as the finding that playing *Mortal Kombat* with the "blood" setting turned on (so that injuries are accompanied by depictions of spurts of blood from the body) led to greater increases in hostility and arousal than with it turned off (Ballard & Wiest, 1996). In this study, the game *content* is equally violent in both cases, but the form is different. Furthermore, in the meta-analysis described above comparing date of study with the size of effect (Gentile & Anderson, 2003), effect sizes have been increasing as games have been becoming more realistic. However, there may be many other reasons for this result, so this interpretation should be viewed with caution. Certainly gamers cite realism as one of the primary facets that are important to them (Wood, Griffiths, Chappell, & Davies, 2004). Future studies will need to be conducted to determine the amount to which realism (and what dimensions of realism) makes a difference.

Mechanics

The types of mechanical input/output devices used to play the games could also show effects. If players play games with identical content, but with varied mechanical interfaces, where some have increased similarity to “reality,” then researchers should be able to document better learning and transfer. For example, playing a driving simulation game with a wheel and pedals should improve driving skill more than playing the same game with a mouse and a keyboard. Similarly, if surgical simulators are designed with input devices that are similar to actual surgical instruments, then learning and transfer should be improved compared to input devices with less verisimilitude. To date, no studies have been conducted to test this hypothesis. This issue is further complicated because mechanics are not entirely independent from form. Game movements are guided both by visual information gathered from the screen and use of the input/output devices, and these inform each other (see Gibson, 1979, for a complete description of how visual information, movement, and proprioception are linked). For example, in a first-person shooter game such as *Halo*, gamers can often shoot at an enemy in a standard game view or through a magnifying “scope” on the weapon. The optics are very different under these two situations, as a small movement with the mouse changes what is seen on the screen a small amount in the standard view, but a large amount when viewed through the scope. Research is needed to determine how mechanics affect video game effects. However, the following anecdote told to me by a graduate student suggests that something about mechanics is learned during game play:

> One evening, I was playing *Halo* with a group of friends. After we were done, we walked outside, and one of my friends yelled "Look out!" similar to the exchanges we had been shouting at each other during the game. Instead of ducking, or looking around, my right hand twitched to move the mouse to move me out of the way.

Conclusions

When attempting to understand all of the varied empirically-identified effects of video games, conceptualizing the effects along the four dimensions of amount, content, form, and mechanics is useful. There are at least two clear benefits to this dimensional approach to understanding video game effects. First, it allows researchers and the public to move beyond the dichotomous thinking that has too often characterized the debate around video games, in which the discussion is reduced to a question of whether video games are *good* or *bad*. As the preceding analysis shows, this is too simplistic a question. The same video game could have both positive and negative effects, depending on what dimension one considers. For example, playing the *Grand Theft Auto* series of games (in which one plays a criminal sociopath) a lot each day could hamper school performance (*amount effect*), increase aggressive thoughts and behaviors (*content effect*), improve visual attention skills (*form effect*), and improve driving skills if one plays with a driver's wheel and pedals or shooting skills if one plays using a gun input/output device (*mechanics effects*).

Second, video games are increasingly being seen by several professions and industries as valuable for training purposes. Until now, educationally motivated games have predominantly focused on curricular aspects (the *content*). Although these have been successful, video game designers may be able to cause even larger effects if all four dimensions are considered as the games are designed. Consider an example of creating surgical simulators for training medical students in laparoscopic techniques. Simulators should have maximum effect if each of the four dimensions are planned.

1. Regarding amount, a certain amount of practice should be required, and it should be distributed practice rather than massed practice.
2. Regarding content, the simulation should include as many variations, complications, and potential errors as possible – in this way, knowledge can transfer across specific examples.
3. Regarding form, the simulation should be as realistic as possible, including as many variations in point of view as possible, and accurate 3D to 2D transformations (including aberrations created by lens distortions).
4. Regarding mechanics, the simulator should include input devices that are similar to surgical tools, and the reactivity shown in the form should be correct (that is, when a tool is moved a small amount, the view should change appropriately).

In this example, the goal would be that when the surgeon is operating on a patient under real pressures and time constraints, and she sees something wrong, she reacts quickly, proportionally, and correctly. This type of automated reaction only comes with repeated exposure and experience – something video games are extremely well designed to provide.

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Table 1: Experimental Studies of Violent Video Games on Affect, Arousal, Cognitions, and Behavior

Experimental Studies on Affect			
Study	*N*	Age	Major Findings
Anderson & Ford (1986)	60	Undergrad	Violent game led to increased hostility and anxiety, but not depression
Calvert & Tan (1994)	36	Undergrad	No change in hostile feelings after playing V virtual reality (VR) game (no NV control)
Scott (1995)	117	Undergrad	Non-linear increase in trait aggressiveness post play; no difference in several personality variables
Hind (1995)	102	15-18 years	Incarcerated adolescents preferred playing games with aggressive actions more than NV games and more than a non-incarcerated control group
Ballard & Wiest (1996)	30	Undergrad	Play on Mortal Kombat with blood resulted in higher hostility scores than Mortal Kombat without blood, which in turn was higher than playing a NV game
Funk, Hagen, & Schimming (1999)	35	3^{rd}-5^{th} graders and parents	Higher, but non-significant, frustration levels after V game
Fleming & Rickwood (2001)	71	8-12 years	V game increased state anger marginally significantly (*p*= .052), while simultaneously improving overall mood compared to a paper-and-pencil task
Ballard, Panee, Engold, & Hamby (2001)	41	12-18 years	V games increased frustration (but were harder to play than NV game)
Ballad & Panee (2001)	36	Undergrad	Greater hostile feelings after playing a V game with aggressive priming instructions compared to non-aggressive instructions
Persky & Blascovich (2004)	?	Undergrad	Greater aggressive feelings after playing a V game, and greater still if played in VR
Farrar & Krcmar (under review)	227	Undergrad	Playing V game increased state hostility

Experimental Studies on Physiological Arousal			
Study	*N*	Age	Major Findings
Winkel, Novak, & Hopson (1987)	56	8^{th} graders	No effect of V or NV games on HR
Calvert & Tan (1994)	36	Undergrad	Increased HR playing V VR game compared to watching or resting
Irwin & Gross (1995)	60	2^{nd} graders	No effect of V or NV games on HR
Ballard & Wiest (1996)	30	Undergrad	Play on Mortal Kombat with or without blood resulted in higher HR and SBP (but not DBP) than playing a NV game
Lynch (1999)	40	9^{th}-12^{th} grade	V game play increased stress hormones (epinephrine & nor-epinephrine) among hostile adolescents
Fleming & Rickwood (2001)	71	8-12 years	V game increased HR and self-reported arousal compared to NV game or pencil-and-paper game
Ballard, Panee, Engold, & Hamby (2001)	41	Adolescents	V games increased frustration (but were harder to play than NV game)
Persky & Blascovich (2004)	?	Undergrad	Greater aggressive feelings after playing a V game in a VR envt, compared to on computer or a NV game
Matsuda & Hiraki (2003)	?	Unknown	Playing a V game (and some NV games) decreases prefrontal cortex activation (indicating attention and less self monitoring) compared to other NV games and to just watching the games
Anderson, Carnagey, Flanagan, Benjamin, Eubanks, &Valentine (2004)	130	Undergrad	Playing V games increased BP compared to NV games, but no differences in HR (although all games increased HR)

Experimental Studies on Aggressive Cognitions

Study	*N*	Age	Major Findings
Graybill, Kirsch, & Esselman (1985)	116	2nd, 4th, & 6th grade	V game increased assertive fantasies and decreased defensive fantasies compared to NV game
Graybill, Strawniak, Hunter, & O'Leary (1987)	79	7-11 years	V games increased aggressive thought accessibility and liking compared to NV games
Calvert & Tan (1994)	36	Undergrad	Increased aggressive thoughts after playing V VR game compared to watching or resting
Kirsh (1998)	52	3rd-4th grade	V game increased hostile attribution bias compared to NV game
Anderson & Dill (2000)	210	Undergrad	V game increased aggressive thoughts compared to matched NV game
Funk, Buchman, Myers, & Jenks (2000)	35	8-12 years	V game increased aggressive thoughts and decreased empathic thoughts, but not significantly
Tamborini, Eastin, Skalski, Lachlan, Feduik, & Brady (2001)	182	Undergrad	V VR game (playing or watching) increased hostile thoughts compared to watching NV game
Bushman & Anderson (2002)	224	Undergrad	V game increased hostile expectations compared to NV game
Funk, Buchman, Jenks, & Bechtoldt (2003)	31 35	5-7 years & 8-12 years	No effect of V game on aggressive story completions or empathy
Anderson, Carnagey, Flanagan, Benjamin, Eubanks, &Valentine (2004)	130	Undergrad	Playing V games increased aggressive thoughts compared to NV games
Anderson et al. (2004)	190	Undergrad	Playing V game did not increase revenge motivation
Anderson et al. (2004)	214	Undergrad	Playing V game did not increase revenge motivation
Bartholow, Sestir, & Davis (under review)	107	Undergrad	
Farrar & Krcmar (under review)	227	Undergrad	Playing V game increased aggressive thoughts and intentions to verbally aggress, but not intentions to physically aggress

Experimental Studies on Aggressive Behavior

Study	*N*	Age	Major Findings
Cooper & Mackie (1986)	84	5th graders	V game increased aggressive toy choice and play for girls, but not aggressive or prosocial behavior (punishment & reward time) toward other children
Graybill, Strawniak, Hunter, & O'Leary (1987)	79	7-11 years	V games did not decrease helpful and increase hurtful responses compared to NV games
Chambers & Ascione (1987)	160	3rd-4th & 7th-8th grades	V games decreased prosocial (money donations) behaviors more more than NV game
Silvern & Williamson (1987)	28	4-6 years	Increased aggressive behavior and decreased prosocial behavior in free play after V game play or violent cartoon viewing (no NV control)
Winkel, Novak, & Hopson (1987)	56	8th graders	No effect of V game on aggressive behavior (money deduction)
Shutte, Malouff, Post-Gorden, & Rodasta (1988)	31	5-7 years	V game increased physically aggressive behaviors to children and toys in free play
Lightdale & Prentice (1994)	74	Undergrad	Males played V game more aggressively than females when introduced to opponents, but equally aggressively when opponents were anonymous
Irwin & Gross (1995)	60	2nd graders	V game increased verbal and physical aggression to a peer in a frustrating situation and to toys in a free-play situation
Ballard & Lineberger (1999)	119	Undergrad	V game increased aggressive behavior (painful stimulus) and decreased prosocial behavior (lower reward) to confederate
Anderson & Dill (2000)	210	Undergrad	V game increased aggressive behavior compared to matched NV game (noise blast)
Bartholow & Anderson	43	Undergrad	V game increased aggressive behavior compared to NV game,

(2001)			with men more affected than women (noise blast)
Durkin & Barber (2002)	1,304	10th graders	High computer game use correlated with greater aggressive behavior compared to low computer game use
Anderson et al. (2004)	190	Undergrad	Playing V game increased aggressive behavior (noise blast)
Anderson et al. (2004)	214	Undergrad	Playing V game increased aggressive behavior (noise blast), red blood did not increase aggression compared to green
Persky & Blascovich (2004)	?	Undergrad	Greater aggressive behavior after playing a V game in a VR envt compared to computer (noise blast)
Bartholow, Sestir, & Davis (under review)	92	Undergrad	Playing V game increased aggressive behavior (noise blast)
Anderson, Gentile, & Buckley (under contract)	615	9-12 years & 17-29 years	Playing V E- and T-rated games increased aggressive behavior (noise blast)

Note: V = Violent, NV = Non-violent; VR = Virtual Reality; HR = Heart Rate, BP = Blood Pressure, SBP = Systolic Blood Pressure, DBP = Diastolic Blood Pressure

Table 2: Cross-Sectional Studies of Violent Video Games on Affect, Arousal, Cognitions, and Behavior

Cross-sectional Studies on Affect			
Wingrove & Bond (1998)	23	Undergrad	Game frustration led to increased discontentment and anxiety (no NV or non-frustrating control)
Durkin & Barber (2002)	1,304	10th graders	High computer game use correlated with greater depressed mood compared to low computer game use
Anderson et al. (2004)	806	Undergrad	Playing V games correlated with lower emotional susceptibility
Bartholow, Sestir, & Davis (under review)	107	Undergrad	V game play correlated with increased hostility
Farrar & Krcmar (under review)	227	Undergrad	Categorical game play not significantly related to hostility
Anderson, Gentile, & Buckley (under contract)	189	14-19 years	V game play correlated with trait hostility and trait anger
Cross-sectional Studies on Physiological Arousal			
Ballad & Panee (2001)	36	Undergrad	Higher use of aggression in game correlated with increased HR and lowered SBP
Cross-sectional Studies on Aggressive Cognitions			
Domonick (1984)	250	10th-11th grade	Arcade game playing (but not home game playing) correlated with aggressive cognitions
Colwell & Payne (2000)	204	12-14 years	Game exposure correlated with aggressive cognitions
Anderson & Dill (2000)	227	Undergrad	Greater violent game play correlated with aggressive personality
Funk, Buchman, Myers, & Jenks (2000)	35	8-12 years	Naming a V game as favorite correlated with aggressive thoughts
Walsh (2000)	137	8th-12th grade	Greater V game exposure correlated with physical fights
Ballad & Panee (2001)	36	Undergrad	Higher use of aggression in game correlated with increased HR and lowered SBP
Funk, Buchman, Jenks, & Bechtoldt (2003)	31 35	5-7 years & 8-12 years	History of V game play correlated with lower empathy
Funk, Baldacci, Pasold, & Baumbardner (2004)	150	4th & 5th grade	Greater V game play positively correlated with proviolence attitudes and negatively correlated with empathy
Krahé & Möller (2004)	231	8th grade	Greater V game play positively correlated with acceptance of physical aggression and indirectly with hostile attribution bias
Gentile, Lynch, Linder, & Walsh (2004)	607	8th & 9th grade	Greater V game play positively correlated with trait hostility
Anderson et al. (2004)	190	Undergrad	History of playing V games correlated with revenge motivation and instrumental aggressive motivation
Anderson et al. (2004)	806	Undergrad	Playing V games correlated with positive attitudes toward violence, lower agreeableness, lower conscientiousness, and higher narcissism
Bartholow, Sestir, & Davis (under review)	107	Undergrad	V game play correlated with lower empathy
Bartholow, Sestir, & Davis (under review)	92	Undergrad	V game play correlated with lower empathy
Farrar & Krcmar (under review)	227	Undergrad	Categorical game play not significantly related to aggressive thought accessibility
Anderson, Gentile, & Buckley (under contract)	189	14-19 years	V game play correlated with positive attitudes to violence in war, attitudes toward intimate partner violence, and normative aggression beliefs

Cross-sectional Studies on Aggressive Behavior			
Domonick (1984)	250	10th-11th grade	Arcade game playing (but not home use) correlated with self-reported physical aggression and aggressive delinquency
McClure & Mears (1986)	290	9th-12th grade	High-rate VG playing not correlated with psychopathic deviance or neuroticism
Lin & Lepper (1987)	189	4th–6th grade	Arcade use of games (but not home use) correlated with teacher ratings of impulsiveness and aggressiveness
Fling, Smith, Rodriguez, Thornton, Atkins, & Nixon (1992)	153	6th-12th grade	Amount of VG play correlated with self-reported and teacher ratings of aggressive behavior
Funk & Buchman (1996)	357	7th & 8th grade	For girls, but not boys, V game play associated with lower self-esteem, poorer behavioral conduct, and other self-perceptions
van Schie & Weigman (1997)	346	7th & 8th grade	Greater amount of video game play negatively correlated with prosocial behavior but not significantly correlated with aggressive behavior
Weigman & van Schie (1998)	278	7th & 8th grade	Greater amount of video game play and preference for violent games negatively correlated with prosocial behavior; preference, but not amount, positively correlated with aggressive behavior
Wingrove & Bond (1998)	23	Undergrad	Game frustration led to increased negative feedback given to a cooperative partner
Colwell & Payne (2000)	204	12-14 years	Game exposure correlated with aggressive behaviors
Anderson & Dill (2000)	227	Undergrad	Greater violent game play correlated with aggressive delinquent behavior and non-aggressive delinquent behavior
Funk, Buchman, & Germann (2000)	364	4th & 5th grade	Preference for violent games correlated with poorer behavioral conduct (self-perception)
Vandewater, Lee, & Shim (2001)	225	7-12 years	Family conflict correlated with increased V game play for girls, but not for boys
Colwell & Kato (2003)	509	12-14 years	Amount of play and V game exposure predicted aggression in samples of UK and Japanese adolescents
Anderson et al. (2004)	214	Undergrad	Playing V games & watching V TV correlated with aggressive behavior (trait physical aggression)
Anderson et al. (2004)	806	Undergrad	Playing V games correlated with mild physical aggression, verbal aggression, severe physical aggression
Gentile, Lynch, Linder, & Walsh (2004)	607	8th & 9th grade	Greater V game play positively correlated with physical fights after controlling for hostility
Bartholow, Sestir, & Davis (under review)	107	Undergrad	V game play correlated with increased physical and verbal aggression
Bartholow, Sestir, & Davis (under review)	92	Undergrad	V game play correlated with increased physical and verbal aggression
Anderson, Gentile, & Buckley (under contract)	615	9-12 years & 17-29 years	V game play correlated with violent behavior
Anderson, Gentile, & Buckley (under contract)	189	14-19 years	V game play correlated with verbal and physical aggression and violent behavior

Note: V = Violent, NV = Non-violent; VR = Virtual Reality; HR = Heart Rate, BP = Blood Pressure, SBP = Systolic Blood Pressure, DBP = Diastolic Blood Pressure

Table 3: Longitudinal Studies of Violent Video Games on Affect, Cognitions, and Behavior

Longitudinal Studies on Affect			
Ballard, Panee, Engold, & Hamby (2001)	41	12-18 years	Repeated play of V games (3 times over 3 weeks) resulted in lower facial displays of disgust and smiling
Ihori, Sakamoto, Kobayashi, & Kimura (2003)	807	5th & 6th grade	Increased amount of video game play (all play, not specifically V games) related to later hostility
Longitudinal Studies on Aggressive Cognitions			
Williams & Skoric (2005)	213	14-68 years	Play of a violent MMORPG for one month did not increase normative beliefs about aggression
Anderson, Gentile, & Buckley (under contract)	430	3rd-5th grade	V VG play early in a school year related to later increases in hostile attribution bias after controlling for sex, race, total screen time, parental involvement, and earlier hostile attribution bias
Longitudinal Studies on Aggressive Behavior			
Ihori, Sakamoto, Kobayashi, & Kimura (2003)	807	5th & 6th grade	Increased amount of video game play related to later indirect aggression (boys & girls) and later physical aggression (boys)
Slater, Henry, Swaim, & Anderson (2003)	2,550	6th & 7th grade	Media violence exposure (including video games) increases aggressive cognitions and behaviors, which in turn increase media violence exposure, which increases aggressive cognitions & behaviors etc. over a two-year period (unable to separate out VGs)
Williams & Skoric (2005)	213	14-68 years	Play of a violent MMORPG for one month was correlated with arguments with friends and with partners, but not with changes in arguments (although frequency of arguments was not measured appropriately to find changes)
Anderson, Gentile, & Buckley (under contract)	430	3rd-5th grade	V VG play early in a school year related to later increases in verbal and physical aggression (as rated by self, peers, and teachers) after controlling for sex, race, total screen time, hostile attribution bias, parental involvement, and earlier verbal and physical aggression

Note: V = Violent, NV = Non-violent; VR = Virtual Reality; HR = Heart Rate, BP = Blood Pressure, SBP = Systolic Blood Pressure, DBP = Diastolic Blood Pressure, MMORPG = Massively Multiplayer Online Role-Playing Games

Figure 1. The General Aggression Model: Distal and Proximal Influences on an Individual Social Episode

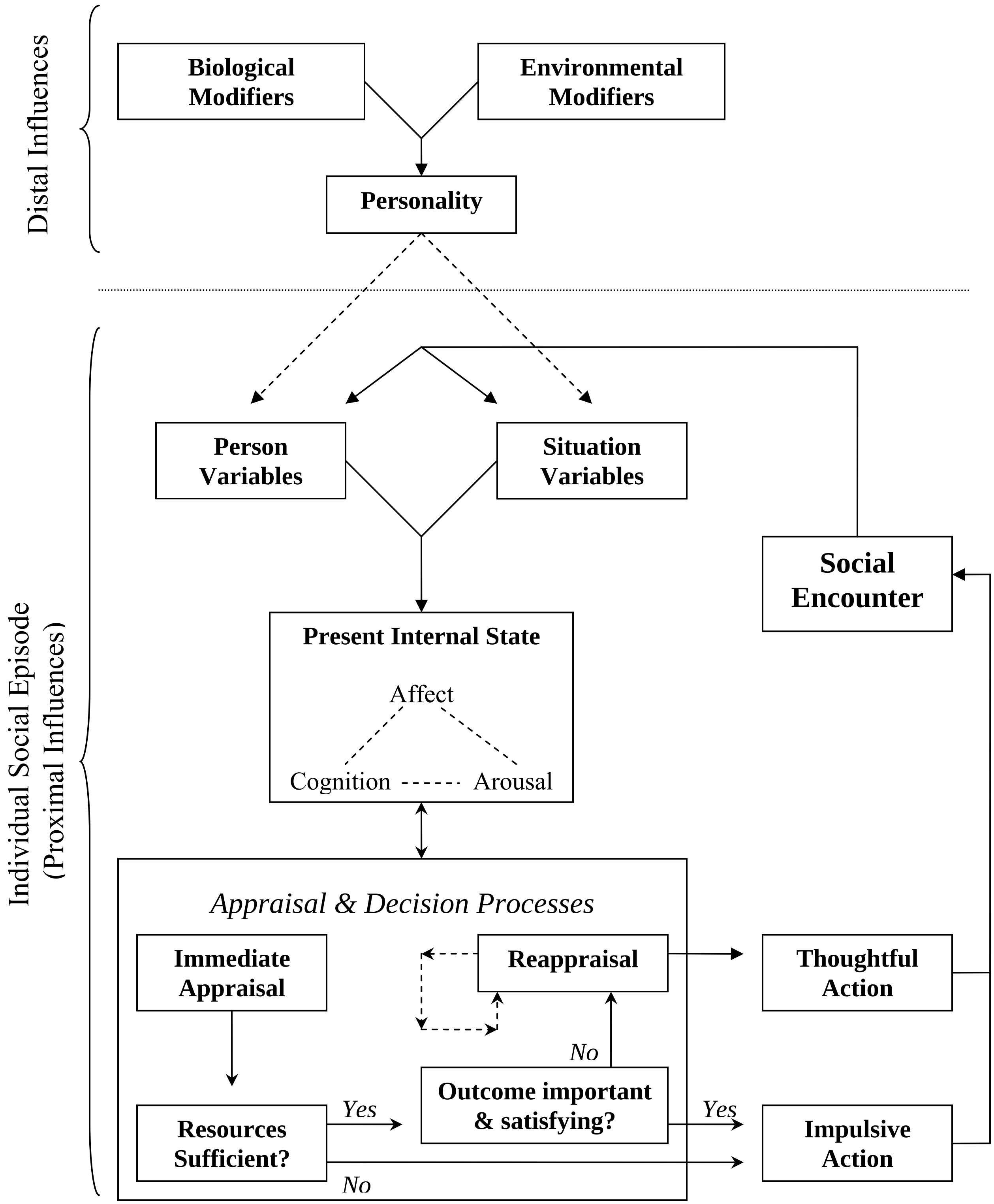

Figure 2. The General Aggression Model: Long-Term Effects of Repeated Exposure to Violent Video Games