Handbook of Research on Effective Electronic Gaming in Education

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Chapter L
Learning Processes and Violent Video Games

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ABSTRACT

Though video games can produce desirable learning outcomes, such as improved performance in school subjects, they also can produce undesirable outcomes, such as increased aggression. Some of the basic learning principles that make video games (particularly violent video games) effective at teaching are discussed in this chapter. A general learning model is presented to explain how video games can produce a variety of effects in their users. This model explains both the immediate, short term effects and cumulative, long term effects of video games. Implications of these principles are discussed in relation to education. The issue of addressing violent video games' effects on aggression is also examined.

LEARNING PROCESSES AND VIOLENT VIDEO GAMES

Video games have become an immensely popular medium in the 35 years since their introduction. The annual sales of video games and their accessories in the U.S. reached $10.5 billion in 2005, exceeding the $9 billion grossed by films in the U.S. box office that same year (ESA, 2007; MPAA, 2007). Though the growth in popularity and sales of video games has been driven more by their ability to entertain than by their ability to teach, many groups, including teachers, businesses, the U.S. military, and researchers, have recognized the value of video games as effective teaching tools. On one hand, video games are effective teaching

tools because they take advantage of several basic learning principles and instructional techniques, such as the use of effective forms of reinforcement and an adaptable level of difficulty. On the other hand, it has come to the public attention that most popular video games, 89% of video games by one estimate, contain violence (Children Now, 2001). This has led to considerable social concern over the potential negative effects of video games, especially the potential of such video games to increase aggression. When examined within the framework of the general learning model (GLM), it is apparent that these divergent outcomes (education and increased aggression) are not competing explanations of video game effects. Rather, both the often intended, positive effects of video games and the unintended negative effects result from the same short-term and long-term psychological learning mechanisms. The success of violent video games as teaching tools suggests ways that education could be improved, both with and without video games. Parents, educators, and policy makers should be aware that video games can teach a wide variety of information and skills and even produce personality changes in their users, for good or ill. What outcomes a particular video game produces depends primarily on its content, regardless of the original intent of the creators or users. This chapter describes some of the principles and mechanisms underlying violent video game effects, as well as some of the societal implications.

What Do Video Games Teach?

Positive Effects

Many groups, including educators, businesses, and military personnel, use video games to teach information and develop skills. Video games have been developed and used effectively to teach a variety of traditional school subjects, such as algebra, geometry, and biology (Corbett, Koedinger, & Hadley, 2001; Ybarrondo, 1984). Other video games are used to teach children skills such as photography and computer programming (Abrams, 1986; Kahn, 1999). Educational video games are effective at improving the development of early math and reading skills in children (Murphy, Penuel, Means, Korbak, Whaley, & Allen, 2002). Video games also have proven effective in helping children with asthma and diabetes to manage their own health behaviors (Lieberman, 1997; McPherson, Glazebrook, Forster, James, & Smyth, 2006). Simulation video games have proven effective in teaching some of the skills that they model as well, from those that teach people with severe learning disabilities how to shop for groceries to games teaching teamwork to pilots (Brannick, Prince, & Salas, 2005; Standen & Cromby, 1996).

Many businesses use educational video games to teach their employees job skills. Cisco teaches their employees about the basic tools of network security with a video game. Volvo uses an online computer game to teach financial and regulatory information to their car sales employees (Flood, 2006). The Mayo Clinic uses a video game called "Name That Congenital Abnormality" to teach residents medical information (Yaman, 2004). Canon reports improvements in training speed due to the use of a video game to teach printer repair skills to their employees, compared to traditional training methods. Video games are not just used by technologically oriented businesses; the ice-cream manufacturer Cold Stone Creamery created a video game to teach employees how to serve ice cream quickly and without errors (*Business Week*, 2007).

The U.S. military extensively uses video games in training. The U.S. Army's Program Executive Office for Simulation, Training, and Instrumentation (PEO STRI) now spends over $2 billion each year creating simulators to train members of the branches of the armed forces (Blake, 2007). These simulators train military personnel for a variety of roles, such as flying helicopters, using weapon systems, and firefighting. The Marines developed

a version of the commercial first-person shooter video game Doom to teach coordination, communication, and teamwork in combat (Prensky, 2001).

Along with this wide variety of deliberate uses to which video games have been applied, some unintended benefits of playing video games have also been observed. Researchers also have found other beneficial effects of video games that were not intended or even known to most of those playing the games. Most notably, some video games can improve certain types of perceptual skills. Video game players are able to pay attention to more cues across their visual field than are non-video game players (Green & Bavelier, 2003). Similarly, laparoscopic surgeons who have played more video games are not only faster at surgical skills, but make fewer mistakes (Rosser, Lynch, Haskamp, Gentile, & Yalif, 2007). Laparoscopic surgery is also called minimally-invasive surgery, in that it involves making several small incisions, and inserting a camera into the body along with surgical instruments on long sticks. The surgeon thus does not see directly into the body, but views the instruments inside the body on a video monitor. Given the nature of laparoscopic surgery, it is perhaps not surprising that there is some transfer from video games. This finding also suggests the potential of video games to be deliberately used to improve laparoscopic surgical skills.

Negative Effects

Of course, not all video game effects are desirable. In particular, much recent research has examined the potential of violent video games to increase aggression in their players. Video game violence research is a subset of the broader area of media violence research. Media violence research began decades before the introduction of video games, much of it examining the effects of television and film violence. The research evidence shows a clear causal link between exposure to media violence and aggression (Anderson et al., 2003). The findings from the video game research are consistent with those from the older television and film violence research. As demonstrated previously, it should not be surprising that video games are capable of teaching aggression given the broad range of knowledge, skills, and behaviors that they can teach.

The effects of violent video games on aggression and aggression-related variables has been observed using experimental, cross-sectional, and longitudinal studies. Cross-sectional studies have been valuable in testing some alternative explanations of the violent video game/aggressive behavior link, such as differences in socioeconomic status, aggressive personality, and other family environment factors. The experimental studies are particularly important, as these provide the strongest evidence that the effect of violent video games on aggression is causal (rather than being due entirely to a preference for violent video games by aggressive individuals, for example). For ethical reasons, laboratory experiments rely on relatively mild forms of aggression (e.g., setting noise blasts for an opponent) as the outcome measure. However, research has demonstrated that such measures are good predictors of how aggressively a person behaves outside of the laboratory and that the same factors that increase aggression in daily life (e.g., heat, provocation) also increase laboratory measures of aggression (Anderson & Bushman, 1997). Though there has been very little longitudinal research on video game effects, the findings are, thus far, consistent with those of other methods in confirming a causal video game violence/aggression link (Anderson, Gentile, & Buckley, 2007). Though public concern for violent video game effects tends to be greatest for children and adolescents, in part because younger children may have difficulty distinguishing fantasy taking place in a video game from reality, the ability to make fantasy and reality distinctions does not seem to make players immune to the effects of violent video games. In fact, research on young adults shows the same pattern of violent video

game effects as research done with children (Gentile & Anderson, 2003). Research has yet to identify a group (in terms of age, sex, or any other factor) that is completely immune to the effects of video game violence.

Meta-analytic reviews of studies have revealed that regardless of the research design type (experimental or cross-sectional), video game violence exposure increases aggressive cognition, aggressive behavior, hostile affect, and physiological arousal, and decreases prosocial behavior (Anderson, 2004; Anderson & Bushman, 2001). The effect sizes observed for these different measures range from small to moderate (*r*s of .15 to .30). To put those in perspective, the effect of video game violence on each of those outcome variables is larger than the effect sizes of many other public health concerns: the effect of asbestos on cancer, calcium intake on bone mass, lead exposure on decreased IQ in children, second hand smoke on lung cancer, and condom use on HIV (Anderson, Carnagey, Flanagan, Benjamin, Eubanks, & Valentine, 2004).

In recent years, research has also demonstrated that video game violence exposure produces physiological desensitization to violence in terms of heart rate, blood pressure, and brain activity (e.g., Bartholow, Bushman, & Sestir, 2006; Carnagey, Anderson, & Bushman, 2006). Like desensitization to specific phobias, in some circumstances this desensitization may be adaptive. For example, soldiers and combat medics are certainly better served by limiting their physiological reactions to violence in order to effectively perform their job. However, there is reason to be concerned about general societal desensitization to violence, as it increases willingness to engage in aggression and decreases empathy for the victims of violence. Recent functional magnetic resonance imaging (fMRI) research demonstrates that video game violence exposure increases activity in the dorsal anterior cingulate cortex (dACC) while decreasing activity in the rostral anterior cingulate cortex (rACC) and amygdala, a pattern of brain activation that is consistent with aggression (Weber, Ritterfeld, & Mathiak, 2006). There is evidence of other negative effects of video game exposure, such as a link between attention deficit hyperactivity (ADHD) symptoms (Chan & Rabinowitz, 2006). Similar associations have been found for television exposure. Though this research has already ruled out a variety of individual and family characteristics as potential alternative explanations for this relationship, more research is needed to test whether the ADHD link is causal.

What Makes Video Games Effective Teachers?

Many commercial video games, including those which are not designed with learning in mind, make use of numerous established instructional principles. A review of these principles, as they relate to video games, not only shows why video games may be more effective than many other forms of instruction or training, but also helps to explain why video games are capable of exerting other powerful effects on their players as well.

One feature found in many video games that improves the ability of players is the choice of multiple difficulty levels. This means that players of varying experience and skill can learn at a pace that matches their ability. This feature is an essential characteristic of many instructional models. Glaser (1962) and Hunter (1982) consider specifying objectives of an appropriate level of difficulty to be important in education. This feature is important in many domains because the pace of learners varies so greatly. In the case of some memory tasks, the pace of the fastest third of children can be over three times as fast as the slowest third, which means that setting a single level of difficulty for all learners is not practical (Gentile & Lalley, 2003; Gentile, Voelkl, Mt. Pleasant, & Monaco, 1995). In the case of violent video games, the difficulty setting generally means that more skillful game players can elect to fight enemies that are more powerful, numer-

ous, or intelligent than those faced by players of lesser ability.

Further, many video games gradually increase the difficulty of the challenges presented as the player progresses through the game. Many first-person shooter games, such as Halo and Call of Duty, begin with a training mission that serves not only to establish the story of the game, but gradually introduces players to the controls of the game, gives them an opportunity to practice these controls to execute abilities, and provides immediate feedback on their performance. In the case of Halo, the game can even adapt to the individual preferences of the player. For example, noting that the player is trying to pull back on the joystick to look up and push forward to look down (which does not correspond to the default control settings) the game can invert the controls to match the preference of the player. As many video games progress, the skills learned at earlier points in the game serve as prerequisites that, once learned, facilitate the learning of more advanced skills. This means that, rather than simply learning a skill and moving on, as is the case in many educational contexts, players continue to apply the skills they have learned earlier as they progress. This design conceptually matches the educational model of the spiral curriculum (Bruner, 1960).

Similarly, this repeated use of skills and information in video games does not stop players at the point of mastery; once mastered, they continue using those skills until they are overlearned. That is, the skills one learns become automatized with further practice, requiring fewer cognitive resources. This means that the player becomes able to focus their conscious effort on more effectively learning, organizing, and applying new information. This overlearning concept has been illustrated in educational contexts, such as reading. A new reader must automatize the recognition of letters and their corresponding sounds before recognizing whole words, and subsequently automatize a number of sight words before focusing attention on the meaning of sentences (Bloom, 1986).

Another advantageous property of video games is that learning is active. That is, a player practices a skill, receives feedback on their performance through the consequences in the game, and then practices the skill again until that skill is mastered (Gee, 2003). This method differs from the outdated (yet still used) practice of having a teacher demonstrate a concept or skill, answering questions, and then moving on to cover another concept. This classroom practice can be problematic in some contexts, because learners cannot ask good questions until they have attempted to use a demonstrated skill. Often, it is not until later, on an exam, that students attempt to demonstrate the concept and subsequently receive feedback. By this time it may be too late for the feedback to be helpful to the learner, because the class has already moved on to learning something else.

One of the most important reasons video games are powerful teachers is their effective use of reinforcement to shape the thinking and behavioral skills of the player. The player is reinforced both intrinsically and extrinsically. The extrinsic rewards can be fairly obvious game features, such as points that a player receives for killing an enemy. However, this also includes less obvious game features, such as the impressive or amusing graphics and sound effects that the player experiences while killing that enemy. Intrinsic rewards occur outside of the game, as a result of having played it. For example, video game players can experience personal satisfaction, a sense of accomplishment and competence, or even increased self-esteem as a result of playing a game (Lieberman, 1998). Video game players may also gain the respect of their peers for accomplishments or skill in playing a video game. Many violent video games (especially multiplayer games, such as Halo 2 or World of Warcraft) are designed in a way that facilitates such social comparisons, rewarding large time investments in the

game. Rewards are not given for every effort in the game. Rather, efforts are intermittently reinforced, a reinforcement schedule which further intensifies the drive to play and progress in the video game. The combination of such extrinsic and intrinsic rewards ensures a high level of attention, repetition, and learning from video games.

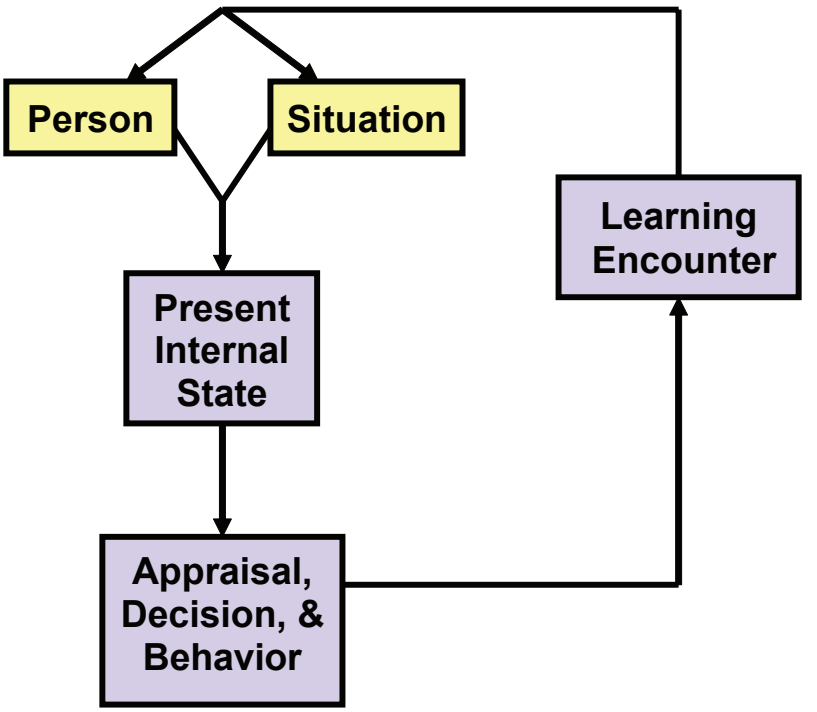
Another result of the effective use of reinforcement by video games is that many players devote considerable amount of time to games. Research has shown that in elementary and middle school, girls spend about six hours per week and boys spend about 13 hours per week playing video games (Anderson, Gentile, & Buckley, 2007; Gentile, Lynch, Linder, & Walsh, 2004). These data were collected several years ago, so the present rate of video game playing is almost certainly higher. One recent national online sample of 8- to 18-year-olds put the estimate at 9 and 16 hours for girls and boys, respectively (Gentile, under review). The large number of hours spent playing at one sitting can be described as massed practice. Although massed practice can produce learning, it eventually begins to have diminishing returns, so a balance in which a large number of hours are played over several days a week should be ideal for learning. For many video game players, their playing time is spread throughout the week in a balance of mass and distributed practice that is close to optimal for learning. There now is empirical evidence that distributed practice with violent video games is associated with a greater increase in aggression, as compared to those who play video games less frequently, even when the amount of time spent playing video games is statistically controlled (Gentile & Gentile, 2008). This finding indicates that many video game players follow a practice schedule, in terms of number and distribution of hours, that maximizes their learning from the video games.

A final educational principle of relevance to video games is that knowledge and skills learned in multiple contexts is more easily transferred and recalled than knowledge or skills which have been learned or practiced in a single context. This may in some cases be due simply to a greater number of cues for recall, making the information less dependent on cues specific to the original context. It may also be due to the ability to develop a more clear and flexible representation of concepts when they are learned in multiple contexts (Bransford, Brown, & Cocking, 1999). For example, learning multiple representations of dividing fractions improves comprehension and transfer to novel situations, compared to spending the same amount of time learning a single method. In the context of violent video games, this principle also suggests that engaging in violence in multiple contexts (e.g., modern, historical, futuristic) and with multiple methods (e.g., shooting people with guns, running them over with cars) should lead to the best transfer of the learned aggression into their lives. There is some evidence that this is the case (Gentile & Gentile, 2008).

How Do Video Games Influence Learning?

The general learning model (GLM) is a useful model for specifying how video games produce a broad range of outcomes in their users (Buckley & Anderson, 2006). This model is an expanded form of the more specific general aggression model (GAM). GAM itself integrates previous aggression theories, such as cognitive neoassociationism (Berkowitz, 1990), affective aggression (Geen, 1990), script theory (Huesmann, 1986), and excitation transfer (Zillman, 1971), with more general social learning and social cognitive theories (e.g., Bandura, 1971, 1973; Mischel & Shoda, 1995) and social information processing models (e.g., Crick & Dodge, 1994). GLM differs from GAM in that the learning processes it describes are not specific to aggression; they can apply to other person environment interactions such as learning from educational video games (Buckley & Anderson, 2006). GLM explains learning through both the short term processes that occur in individual learn-

Figure 1. The general learning model, simplified view (Copyright 2006 Lawrence Erlbaum Associates. Used with permission)



ing episodes, as well as the cyclical process by which these episodes produce long term changes in the learner (see Figure 1 for a representation of a single learning encounter from the GLM). Though GLM is not specific to learning from video games, it is useful for understanding video game learning outcomes.

Input Variables

There are two broad types of input variables in a learning encounter: person variables and situation variables. Person variables are the existing characteristics of the learner: mood state, past experiences, prior knowledge, beliefs, goals, attitudes, and other personality traits. Many of these variables tend to be somewhat consistent over time and in different situations, as the same knowledge structures (e.g., scripts or expectation schemata) will generally guide behavior. Situation variables are the characteristics of the environment in which the learning encounter is occurring. Situation variables include the location, other people present, and media (such as video games) that are present during the encounter. It should be fairly obvious that situational variables vary greatly over time, yet for each individual are likely to show some consistency, as people tend to be in similar situations across time. For example, a college student will find themselves in classroom situations more frequently than non-students.

Learning encounters involving video games are subject to many of the same person variables that affect other sorts of learning, for example, age, intelligence, income level, and self-esteem (Lieberman, 1998). However, other person variables are more specific to learning from video games, such as the individual's media exposure history. The extent to which aggression is learned from violent video games can be influenced by factors such as the player's sex, age, social problem

solving ability, experiences of victimization, prior aggressiveness, and level of parental supervision (Anderson & Bushman, 2002). Some situational variables can be specific to learning from video games as well, most notably characteristics of the video game itself. The amount of interest a game creates, the amount of time it is played (both the frequency and duration), how the game is structured, reinforcement contingencies, and game content all influence what is learned and how well it is learned. The style of game play is also important to learning from a video game. Some games rely on drill-and-recall of facts while other video games attempt to simulate reality, and different types of video games can lead to different things being learned (Murphy et al., 2002; Squire, 2003). Situational variables such as frustration, pain, or aggressive cues (e.g., the presence of a weapon) can affect how violent video games influence aggression (Anderson & Bushman, 2002).

These person and situational input variables can even combine in interactive ways to facilitate or impair learning. For example, when children with low self-esteem play a video game of appropriate difficulty that features a character similar to themselves, their self-esteem tends to improve (Lieberman, 1998). Individuals who are higher in trait hostility tend to show a disproportionate increase in aggressive cognitions in response to pain (Anderson, Anderson, Dill, & Deuser, 1998). In these examples, person factors (low self-esteem or trait hostility) interact with situation factors (similar video game character or pain), yet the result is either increased self-esteem or increased aggressive cognitions, depending on the specific input variables.

Present Internal State

The effect of the person and situational input variables on learning and behavior occurs through the individual's present internal state, consisting of cognition, affect, and arousal states. Cognition, affect, and arousal are each influenced not only by the input variables, but also by both of the other two types of present internal state variables.

Cognition. A variety of cognitive variables can be influenced by input variables: attributions, conscious thoughts, beliefs, perceptual and expectation schemata, and behavioral scripts. In the case of behavioral scripts, when a particular script becomes activated, it influences which behaviors are likely to occur (Huesmann, 1986). For example, the presence of other students sitting in a classroom very quietly (a situational variable) could lead to the activation of a script for listening to a boring lecture (a behavioral script), subsequently influencing the learning that occurs by leading the individual to ignore the instructor. In some cases, the activation and influence of such knowledge structures can occur automatically and completely outside conscious awareness (Schneider & Shiffrin, 1977; Todorov & Bargh, 2002). In other cases, the cognitive processes are initially conscious and become automatized with repeated practice.

Affect. Personal and situational variables can also influence an individual's affective state. This principle is demonstrated by phenomena such as mood-congruent cognition, mood dependent memory, and the mere exposure effect. Mood-congruent cognition means that people are better able to process information that is consistent with their present mood. In other words, angry people process aggression-related information more easily. Aversive stimulation, such as heat, can increase negative affect (Anderson, Anderson, Dorr, DeNeve, & Flanagan, 2000). Consequently, the ability of violent video games to teach aggression could be intensified by playing the game in a hot room. Mood dependent memory, on the other hand, describes people's ability to recall information better when they are in the same mood as when they originally learned that information. This explains why depressed people can recall negative information more easily than positive information (Berry, 1997). The mere exposure

effect describes the tendency for an object's attractiveness to increase simply through repeated exposure to it. One need not even be aware of that exposure to be affected by it (Kunst-Wilson & Zajonc, 1980). Though this principle often occurs with stimuli that are initially slightly positive or neutral, it can also occur with stimuli that initially produce a negative reaction, as is the case with systematic desensitization. Presenting a stimulus that is initially fearful or disturbing (e.g., images of graphic violence) within a positive context (e.g., a fun video game) can produce desensitization to the stimulus (Carnagey, Anderson, & Bushman, 2006).

Arousal. Playing video games, whether they are violent or not, tends to produce physiological arousal. This is useful for learning from video games, as players who did not experience arousal might be too bored to pay attention and learn from the game. On the other hand, if a player is too physiologically aroused, learning can be inhibited (Deshpande & Kawane, 1982; Yerkes & Dodson, 1908). Increased arousal more easily disrupts the learning of less familiar information, as compared with well-learned material (Berkowitz, 1990). This suggests that video games have an optimal level of arousal for stimulating learning, though the effects of excessive arousal may be less of an issue in cases where the video game is sufficiently familiar for the player.

Interactions. Though GLM specifies three distinct internal state properties (cognition, affect, and arousal), these are not entirely separate routes of influence on learning. Both cognition and affect can potentially influence arousal (Schachter & Singer, 1962), and cognition and arousal can likewise influence affect (Bower, 1978). For example, if a violent video game makes the player angry, this could lead to the activation of a hostile expectancy schema. That schema could further increase the likelihood of an aggressive behavior in response to some sort of provocation occurring outside the video game.

Immediate Outcomes

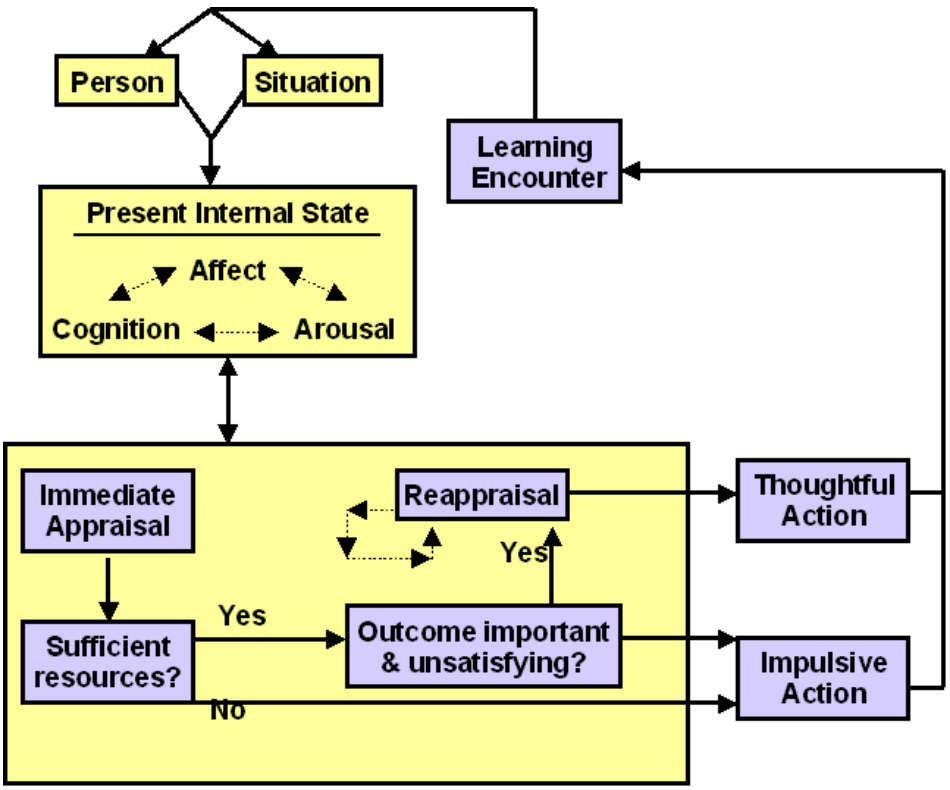
The present state of cognition, affect, and arousal lead to an appraisal process, which in turn determines the immediate behavioral outcome (see Figure 2). The appraisal process may be thoughtful or impulsive. A thoughtful appraisal will take place only when the individual finds the result of the initial appraisal sufficiently unsatisfying and has sufficient resources (i.e., attention and time) for further consideration. Note that in most violent video games, the player will often not have sufficient time or attentional resources for reappraisal in violent encounters. Although, if the player makes a poor decision and loses in the game, that is likely remembered when the player tries again. In either case, the decision making process will potentially produce some type of learning. The outcome of this learning trial will then have an impact on the inputs of subsequent learning encounters. Playing a video game represents a series of successive learning encounters, each one lasting perhaps only a few seconds or even hours.

Long Term Effects

The different stages of the general learning model discussed so far, from the personal and situational input variables to the immediate outcome, represent a single learning encounter in which a person might learn a fact or experience short-term changes. Similar, repeated learning encounters can produce a variety of long-term changes in an individual over time. One of the long-term changes that playing video games can produce is increased factual knowledge. Most educational software of the drill-and-recall variety is intended to meet this goal. Video games, especially those that are designed to simulate reality, can also teach behaviors.

One of the most important long-term effects of video games is the potential for these games to alter the knowledge structures (beliefs, attitudes,

Figure 2. The general learning model, expanded causes and processes (Copyright 2006 Lawrence Erlbaum Associates. Used with permission)



behavioral scripts, perceptual and expectation schemata, and affective traits) of their users. Changes in knowledge structures also leads to changes in personality (Mischel & Shoda, 1995; Sedikides & Skowronski, 1990). For example, repeatedly playing violent video games in which disagreements are settled with violence can lead to the development of a behavioral script of disagreement that includes physical aggression. As this script is activated from repeatedly playing such video games, it should become strengthened to the point where it becomes more easily activated in general. This could make an individual more conflict prone and willing to resort to physical aggression in situations of conflict. On the other hand, if the same individual were to instead play video games in which conflicts are settled with peaceful discussion and compromise, this could eventually lead to a more prosocial personality.

Not only do such changes in personality alter the personal variables that an individual brings to future learning encounters, but it can influence the situational input variables as well. For example, if a person develops an expectation of hostile interactions with peers, they may begin to seek out or even create such situations (Anderson, Buckley, & Carnagey, under review), and their peer group also is likely to change in ways that provide them with more opportunities to behave aggressively and confirming their expectations when those situations arise. To the extent that educational video games improve school performance, they could lead to better relationships with parents and teachers and change their peer group, leading to more opportunities for educational advancement.

Where Do We Go From Here?

Apply Effective Teaching Principles of Video Games

One potential benefit provided by awareness of properties that make video games effective teaching tools is that these properties can be more systematically applied. Many of these points can be applied not just with educational video games, but in other educational contexts as well. Rather than trying to cover every concept, educational games tend to focus on fewer concepts but make learners practice them not just to the point of mastery, but to the point of overlearning. Even when a high initial standard of recall is used, learners tend to forget much of what they learn over time. Overlearning can help reduce this decline. This goal of overlearning can be achieved by teaching the same concepts in multiple ways within a video game. Similarly, new concepts should be explicitly connected to previously learned concepts, as in the spiral curriculum (Bruner, 1960).

Another property of violent video games that is worth applying further is effective reward systems. Though it is popular in some educational contexts to reward any effort with praise, many video games utilize a more effective system of reinforcement. Though the initial difficulty level is adjusted to the individual, the extrinsic rewards (e.g., points, new abilities, better weapons) are given based on the increased level of competence the player achieves. This helps the player monitor their competence in the game, rather than undermining the intrinsic reinforcement that comes from developing greater competence by giving praise without regard to the quality of their performance.

The Issue of Video Game Violence

That violent video games increase aggression is well understood by psychologists. Future research will continue to reveal more details about the mediating processes (e.g., physiological desensitization), corresponding brain activity, and brain substrates (e.g., the ACC and amygdala). However, the collective research to date on video game violence and aggression is sufficient to warrant public concern and efforts to address this problem. Such efforts are unlikely to be successful until these conclusions are more widely accepted. Resistance to the research findings results from multiple factors, some of which are beyond the scope of the present work. This resistance is startling, because many of the most vocal nay-sayers also promote the positive educational benefits of video games. As we have attempted to demonstrate, the psychological learning mechanisms are identical regardless of whether the game content features math or violence. Therefore, learning is likely to occur in both cases, not simply the one we prefer. In this section we address two factors: lack of understanding of the scientific meaning of "causality" and fear of the implications of accepting the conclusion that violent video games increase aggression. We also suggest some reasonable steps to reduce the effects of video game violence.

The implicit definition of causality is relevant because the argument is often made that "many people play violent video games without demonstrating aggression, so therefore violent video games cannot cause aggression." This argument presupposes that researchers are using the *necessary and sufficient* form of causality. To support this narrow and extreme form of causality, all people who play violent video games would have to behave aggressively and all aggressive people would have to play violent video games. No media violence researcher has made this argument. Instead, researchers use causality in the more modern, probabilistic sense. In other words, playing violent video games is one of many variables (risk factors) that increases the probability of an individual behaving aggressively. No single risk factor is sufficient to produce violent behavior, just as no single risk factor will be present in all acts of aggression.

Reluctance to accept the conclusion that violent video games cause aggression can also be based on the fear that, if it were true, it would become necessary to ban violent video games. Such a fear appears to underlie both the industry's and violent game players' denials of the conclusions by the research community. This is a misunderstanding of the role of science in determining public policy. Scientific facts are just one of the factors that contributes to effective public policy (Anderson & Gentile, 2008). Public policy must also be based on legal issues, personal values, and political realities. Also particularly relevant to this question of public policy are personal values of legislators and of the general public. Just because something is known to be harmful does not mean it must be banned. Just because certain foods contribute to heart disease does not necessitate banning those foods, though it does suggest being careful about what you eat. Similarly, if people gave more attention to their media diets and the media diets of their children, the potentially harmful effects could be reduced.

There are reasonable steps that can be taken to reduce their negative impact on children without resorting to a legal action. These have been described as the three pillars of responsibility (Gentile & Anderson, 2003). The first pillar is that the video game industry should accurately label their products to indicate their content, and explain this rating system to parents. This industry should also ethically market their products (e.g., avoid marketing violent games to children and adolescents) and should explain why it is important that parents use the ratings (i.e., because there is evidence of games having harmful effects as well as positive effects). The second pillar of responsibility is that the retail and rental industries should make reasonable efforts to enforce appropriate restrictions based on the content labels. The third pillar of responsibility lies with parents, who should educate themselves about the meanings of the media ratings systems, should learn *why* they need to monitor the content and time spent playing video games by their children, and then should act on that knowledge. For a broader discussion of public policy options about media violence, see Gentile, Saleem, & Anderson (2007).

CONCLUSION

It is evident that video games teach a variety of types of information, skills, and behaviors. Some of this learning is intentional and beneficial (e.g., software designed to teach school subjects), but other forms of learning, such as increased aggressiveness from playing violent video games, occurs even though it is not intended by the creators or players of these video games. The specific outcomes are dependent on the content of the video game. Those who create and use video games in education should be aware that a single video game can have multiple effects on their users. For example, a video game in which the player must solve math problems in order to destroy enemies might simultaneously increase math knowledge and aggressive attitudes.

Popular video games frequently make use of a variety of effective teaching principles that make them powerful at teaching whatever their content happens to be. Those who wish to create effective educational video games would do well to consider these principles.[1] Specifically, an effective video game will allow players to choose the difficulty level of the video game and gradually increase the challenge as a player's skill increases. Skills learned in the beginning of a game should be practiced to the point of automatization and continually utilized as new skills are practiced. Educational video games should be made to take advantage of the ability to provide immediate feedback. The system of reinforcement is a critical component of an educational video game. The most effective games at motivating players will make use of both extrinsic reinforcement (e.g., points or impressive visual effects) and intrinsic

reinforcement (e.g., a sense of accomplishment or competence).

The GLM provides a useful framework for understanding how video games exert short term and long term effects on their users. This model shows that learning does not simply mean acquiring information, but potentially changing behavior and personality as well. Video games are clearly a powerful tool and, like any effective tool, care should be taken in how they are used.

REFERENCES

Abrams, A. (1986, January). *Effectiveness of interactive video in teaching basic photography skills.* Paper presented at the Annual Convention of the Association for Educational Communication and Technology, Las Vegas, NV.

Anderson, C. A. (2004). An update on the effects of violent video games. *Journal of Adolescence, 27,* 113-122.

Anderson, C. A., Anderson, K. B., Dorr, N., DeNeve, K. M., & Flanagan, M. (2000). Temperature and aggression. *Advances in Experimental Social Psychology*, *32*, 63-133.

Anderson, C. A., Berkowitz, L., Donnerstein, E., Huesmann, L. R., Johnson, J. D., Linz, D., Malamuth, N. M., & Wartella, E. (2003). The influences of media violence on youth. *Psychological Science in the Public Interest, 4,* 81-110.

Anderson, C. A., Buckley, K. E., & Carnagey, N. L. (under review). *Creating your own hostile environment: A laboratory examination of trait aggression and the violence escalation cycle.*

Anderson, C. A., & Bushman, B. J. (1997). External validity of "trivial" experiments: The case of laboratory aggression. *Review of General Psychology, 1,* 19-41.

Anderson, C. A., & Bushman, B. J. (2001). Effects of violent video games on aggressive behavior, aggressive cognition, aggressive affect, physiological arousal, and prosocial behavior: A meta-analytic review of the scientific literature. *Psychological Science, 12,* 353-359.

Anderson, C. A., & Bushman, B. J. (2002). Human aggression. *Annual Review of Psychology*, *53*, 27-51.

Anderson, C. A., Carnagey, N. L., Flanagan, M., Benjamin, A. J., Eubanks, J., & Valentine, J. C. (2004). Violent video games: Specific effects of violent content on aggressive thoughts and behavior. *Advances in Experimental Social Psychology*, *36*, 199-249.

Anderson, C. A., & Gentile, D. A. (2008). Media violence, aggression, and public policy. Chapter to appear in E. Borgida & S. Fiske (Eds.), *Beyond common sense: Psychological science in the courtroom.* Oxford, UK: Blackwell.

Anderson, C. A., Gentile, D. A., & Buckley, K. (2007). *Violent video game effects on children and adolescents: Theory, research, and public policy.* New York: Oxford University Press.

Anderson, K. B., Anderson, C. A., Dill, K. E., & Deuser, W. E. (1998). Th e interactive relations between trait hostility, pain, and aggressive thoughts. *Aggressive Behavior*, *24*, 161-171.

Bandura, A. (1971). Social learning of moral judgments. *Journal of Personality & Social Psychology, 11,* 275-279.

Bandura, A. (1973). *Aggression: A social learning analysis.* Oxford, England: Prentice-Hall.

Bartholow, B. D., Bushman, B. J., & Sestir, M. A. (2006). Chronic violent video game exposure and desensitization to violence: Behavioral and event-related brain potential data. *Journal of Experimental Social Psychology, 42,* 532-539.

Berry, G. E. (1997). Information processing in anxiety and depression: Attention responses to

mood congruent stimuli. *Dissertation Abstracts International, 58*(2-B), 967.

Berkowitz, L. (1990). On the formation and regulation of anger and aggression: A cognitive-neoassociationistic analysis. *American Psychologist, 45,* 494-503.

Blake, J. T. (2007). *State of the PEO.* Retrieved February 28, 2007, from http://www.peostri.army.mil/ABOUTUS/FILES/StateOfThePEO.pdf

Bloom, B. S. (1986). Automaticity: The hands and feet of genius. *Educational Leadership, 43*(5),70-77.

Bower, G. H. (1978). Emotional mood as a context for learning and recall. *Journal of Verbal Learning and Verbal Behavior*, *17*, 573-585.

Brannick, M. T., Prince, C., & Salas, E. (2005). Can PC-based systems enhance teamwork in the cockpit? *International Journal of Aviation Psychology, 15,* 173-187.

Bransford, J. D., Brown, A. L, & Cocking, R. R. (Eds.) (1999). *How people learn: Brain, mind, experience, and school*. Washington, DC: National Academy Press.

Bruner, J. (1960). *The process of education*. New York: Vintage.

Buckley, K. E., & Anderson, C. A. (2006). A theoretical model of the effects and consequences of playing video games. Chapter in P. Vorderer & J. Bryant (Eds.), *Playing computer games: Motives, responses, and consequences* (pp. 363-378). Mahwah, NJ: LEA.

Business Week (Business Week Online.) (2007). *On-the-job video gaming.* Retrieved February 28, 2007, from http://www.businessweek.com/magazine/content/06_13/b3977062.htm

Carnagey, N. L., Anderson, C. A., & Bushman, B. J. (2006). Th effect of video game violence on physiological desensitization to real-life violence. *Journal of Experimental Social Psychology*, *43*(3), 489-496.

Chan, P. A., & Rabinowitz, T. (2006). A cross-sectional analysis of video games and attention deficit hyperactivity disorder symptoms in adolescents. *Annals of General Psychiatry, 5*(16).

Children Now. (2001, December). *Fair play? Violence, gender and race in video games*. Sacramento, CA: Author.

Corbett, A. T., Koedinger, K. R., & Hadley, W. (2001). Cognitive tutors: From the research classroom to all classrooms. In P. S. Goodman (Ed.), *Technology enhanced learning* (pp. 235-263). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Crick, N. R., & Dodge, K. A., (1994). Social information-processing mechanisms in reactive and proactive aggression. *Child Development, 67,* 993-1002.

Deshpande, S. W., & Kawane, S. D. (1982). Anxiety and serial verbal learning: A test of the Yerkes-Dodson law. *Asian Journal of Psychology and Education*, *9*, 18-23.

ESA (Entertainment Software Association). (2007). Retrieved July 12, 2007, from http://www.theesa.com/files/VideoGames-Final.pdf

Flood, S. (2006). All play and more work. *Computing.* Retrieved June 20, 2007, from http://www.computing.co.uk/computing/analysis/2152597/play-work

Gee, J. P. (2003). *What video games have to teach us about learning and literacy.* New York: Palgrave Macmillan.

Geen, R. G. (1990). *Human aggression: Mapping social psychology series.* Belmont, CA: Brooks/Cole Publishing Co.

Gentile, D. A. (under review). *Pathological video game use among youth 8 to 18: A national study.*

Gentile, D. A., & Anderson, C. A. (2003). Violent video games: The newest media violence hazard. In D. Gentile (Ed.), *Media violence and children* (pp. 131-152). Westport, CT: Praeger.

Gentile, D. A., & Gentile, J. R. (2008). Violent video games as exemplary teachers: A conceptual analysis. *Journal of Youth and Adolescence.*

Gentile, D. A., Lynch, P. J., Linder, J. R., & Walsh, D. A. (2004). The effects of violent video game habits on adolescent aggressive attitudes and behaviors. *Journal of Adolescence, 27*, 5-22.

Gentile, D. A., Saleem, M., & Anderson, C.A. (2007). Public policy and the effects of media violence on children. *Social Issues and Policy Review, 1,* 15-61.

Gentile, D. A., & Stone, W. (2005). Violent video game effects on children and adolescents: A review of the literature. *Minerva Pediatrica, 57,* 337-358.

Gentile, J. R., & Lalley, J. (2003). *Standards and mastery learning: Aligning teaching and assessment so all children can learn*. Thousand Oaks, CA: Corwin.

Gentile, J. R., Voelkl, K. E., Mt. Pleasant, J., & Monaco, N. M. (1995). Recall after relearning by fast and slow learners. *Journal of Experimental Education, 63*, 185-197.

Glaser, R. (1962). Psychology and instructional technology. In R. Glaser (Ed.), *Training research and education* (pp. 1-30). Pittsburgh, PA: University of Pittsburgh Press.

Green, C. S., & Bavelier, D. (2003). Action video game modifies visual selective attention. *Nature, 423*, 534-537.

Huesmann, L. R. (1986). Psychological processes promoting the relation between exposure to media violence and aggressive behavior by the viewer. *Journal of Social Issues, 42,* 125-139.

Hunter, M. (1982). *Mastery teaching.* El Segundo, CA: Tip Publications.

Kahn, K. (1999, June). *A computer game to teach programming.* Paper presented at the National Educational Computing Conference, Atlantic City, NJ.

Khoo, A., & Gentile, D. A. (2007). Problem based learning in the world of games. In O. S. Tan & D. Hung (Eds.), *Problem-based learning and e-learning breakthroughs* (pp. 97-129). Singapore: Thomson Publishing.

Kunst-Wilson, W. R., & Zajonc, R. B. (1980). Affective discrimination of stimuli that cannot be recognized. *Science*, *New Series*, *207*, 557-558.

Lieberman, D. A. (1997). Interactive video games for health promotion: Effects on knowledge, self-efficacy, social support, and health. In R. L. Street, Jr., & W. R. Gold, (Eds.), *Health promotion and interactive technology: Theoretical applications and future directions. LEA's communication series* (pp. 103-120). Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.

Lieberman, D. A. (1998, July). *Health education video games for children and adolescents: Theory, design, and research findings.* Paper presented at the Annual Meeting of the International Communication Association, Jerusalem, Israel.

McPherson, A. C., Glazebrook, C., Forster, D., James, C., & Smyth, A. (2006). A randomized, controlled trial of an interactive educational computer package for children with asthma. *Pediatrics, 117,* 1046-1054.

Mischel, W., & Shoda, Y. (1995). A cognitive-affective system theory of personality: Reconceptualizing situations, dispositions, dynamics, and invariance in personality structure. *Psychological Review, 102,* 246-268.

MPAA (Motion Picture Association of America). (2007). Retrieved July 12, 2007, from http://www.mpaa.org/US%20Theatrical%20Snapshot.pdf

Murphy, R. F., Penuel, W. R., Means, B., Korbak, C., Whaley, A., & Allen, J. E. (2002). *E-DESK: A review of recent evidence on the effectiveness of discrete educational software.* (Prepared for: Planning and Evaluation Service, U. S. Department of Education.) SRI International.

Prensky, M. (2001). *Digital game-based learning.* New York: McGraw Hill.

Rosser, J. C., Lynch, P. J. Haskamp, L., Gentile, D. A., & Yalif, A. (2007). The impact of video games in surgical training. *Archives of Surgery, 142,* 181-186.

Schachter, S., & Singer, J. (1962). Cognitive, social, and physiological determinants of emotional state. *Psychological Review*, *69*, 379-399.

Schneider, W., & Shiffrin, R. M. (1977). Controlled and automatic human information processing: I. Detection, search, and attention. *Psychological Review, 84,* 1-66.

Sedikides, C., & Skowronski, J. J. (1990). Towards reconciling personality and social psychology: A construct accessibility approach. *Journal of Social Behavior & Personality, 5,* 531-546.

Squire, K. (2003). Video games in education. *International Journal of Intelligent Simulations and Gaming, 2*.

Standen, P. J., & Cromby, J. J. (1996). Can students with developmental disability use virtual reality to learn skills which will transfer to the real world? In H. J. Murphy (Ed.), *Proceedings of the Third International Conference on Virtual Reality and Persons with Disabilities*. Northridge, CA: California State University Center on Disabilities.

Todorov, A., & Bargh, J.A. (2002). Automatic sources of aggression. *Aggression & Violent Behavior, 7,* 53-68.

Weber, R., Ritterfeld, U., & Mathiak, K. (2006). Does playing violent video games induce aggression? Empirical evidence of a functional magnetic resonance imaging study. *Media Psychology, 8,* 39-60.

Yaman, D. (2004). *Why games work*. Retrieved May 2, 2004, from http://learningware.com/clients/gameswork.html

Ybarrondo, B.A. (1984). *A study of the effectiveness of computer-assisted instruction in the high school biology classroom*. Idaho. (ERIC Document Reproduction Service No. ED265015).

Yerkes, R. M., & Dodson, J. D. (1908). The relation of strength of stimulus to rapidity of habit formation. *Journal of Comparative Neurology & Psychology*, *18*, 459-482.

Zillmann, D. (1971). Excitation transfer in communication-mediated aggressive behavior. *Journal of Experimental Social Psychology, 7,* 419-434.

KEY TERMS

Aggression: Behavior which is carried out with the intent to harm another individual who is motivated to avoid that harm.

Automatize: Making a cognitive process relatively effortless and requiring few or no cognitive resources, usually achieved through repetition.

Knowledge Structure: Packet of organized information about the world, held in long-term memory.

Overlearning: To continue studying or practicing a perceptual, thought, or decision process, or a skill after initial proficiency has been achieved, in order to reinforce or ingrain the learned information or skill.

Schema: A pattern or template used to understand real-world experiences, to mediate perception, or guide response. A type of knowledge structure.

Script: A schema containing an expected sequence of behaviors used to attain a particular goal.

Violence: Extreme physical aggression, such as severe physical assault or murder. All violence is aggression, but not all aggression is violence.

ENDNOTE

[1] A different level of analysis suggests that there are at least four dimensions on which video games have effects, including amount, content, structure, and mechanics (Gentile & Stone, 2005; Khoo & Gentile, 2007). We have focused almost entirely on the content dimension here, but software developers should also consider the others if the goal is maximally effective games.