CHAPTER 66

# The Influence of Video Games on Social, Cognitive, and Affective Information Processing

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**Abstract**

This chapter first reviews literature examining the effects of video games from the perspective of social, cognitive, affective, and education science. It also considers how knowledge from social and cognitive neuroscience may serve to enhance our understanding of the effects of video game experience. The literature reveals some paradoxical effects wherein experience with the same types of games can lead to an increase in aggression, a decrease in cognitive control, and an increase in visuospatial abilities. A consideration of the behavioral, neuroanatomical, and physiological bases of the effects of video games leads to the suggestion that exposure to these media is associated with plasticity within neural networks supporting high level vision, emotion processing, cognitive control, and social decision making. Future investigations focusing on within and between domain comparisons using behavioral and neuromonitoring techniques are likely to provide greater insight into neural basis of the effects of video games.

**Keywords:** attention, cognition, cognitive control, emotion, executive control, individual differences, negativity bias, video games, video game violence, visuospatial cognition

## Introduction

Computer and console-based video games represent a pervasive form of leisure activity in industrialized nations beginning in early to middle childhood and continuing through adulthood. A recent representative sample of U.S. teens found that 99% of boys and 94% of girls had played video games (Lenhart, et al., 2008). Boys typically play more than girls (Rideout, Roberts, & Foehr, 2005). For example, a survey of over 600 eighth and ninth grade students found that boys averaged 13 hours per week and girls averaged 5 hours per week (Gentile, Lynch, Linder, & Walsh, 2004). In addition to the entertainment value of video games, evidence from a growing number of studies demonstrates that video games can produce positive pedagogical outcomes related to the development of health-related knowledge and behaviors (Baranowski, Buday, Thompson, & Baranowski, 2008; Barlett, Anderson, & Swing, 2009) and military training (Gopher, Weil, & Bareket, 1994).

Widespread use of video games begs the question of what intended and unintended effects they may produce. There is not a simple answer to this question. For instance, exposure to a specific type of game (e.g., violent action games) might have multiple effects including increases in aggression (Anderson & Bushman, 2001) and improvements in visuospatial cognition (Green & Bavalier, 2003). Because games differ on a range of dimensions and engage various cognitive, affective, and behavioral systems, it is reasonable to expect that they will influence multiple information processing systems (Gentile & Gentile, 2008). Indeed, there is growing evidence for a wide range of video game effects that influence social and antisocial behaviors, cognitive styles, and affective processing (Barlett et al., 2009). Furthermore, some of these effects may be moderated by personal characteristics (e.g., gender) or by social circumstances (e.g., parental involvement). Thus, the potential positive or negative effects of video game experience must be considered within the socio-cognitive-cultural context where the individual is embedded. With this in mind, the goals of the current chapter were twofold. First, we provide a review of the literature examining the effects of video games from the perspective of social, cognitive, affective, and education science. Second, we briefly consider how knowledge from social and cognitive neuroscience may serve to enhance our understanding of the effects of video game experience.

## Video Games: Social, Cognitive, Affective, and Education Science

### *Social Science*

Building on a nearly 50-year tradition considering the effects of violence in television and film, the last decade has witnessed the blossoming of research examining the impact of video game violence (VGV) on aggression. At least some of this interest seems to be motivated by the commonly observed association between high levels of consumption of VGV and violent crime sprees committed by adolescents (e.g., West Paducah, Kentucky (December, 1997); Littleton, Colorado (April, 1999); Wellsboro, Pennsylvania (June, 2003)). Laboratory studies of the relationship between exposure to VGV and aggression demonstrate that brief exposure (e.g., 15–30 minutes) to violent content during game play can result in increases in aggressive thoughts and actions (Anderson, et al., 2004). Complementing this evidence, cross-sectional and longitudinal studies demonstrate that chronic exposure to VGV may represent a unique predictor of instances of aggression outside the laboratory (Anderson et al., 2004; Anderson, Gentile, & Buckley, 2007; Anderson et al., 2008).

The research examining the effects of VGV on aggression can be understood within the context of the *general aggression model* (GAM; Anderson & Bushman, 2002). GAM is a bio-social-cognitive theory designed to account for both short-term and long-term effects of exposure to media violence (Figure 66.1). Repeated exposure to, and reinforcement of, aggression that is embodied in violent video games can lead to the development of aggressive beliefs and attitudes, perceptual schemata, expectations, behavior scripts, and desensitization to aggression (Figure 66.2). Together, the development of these knowledge structures can lead to an

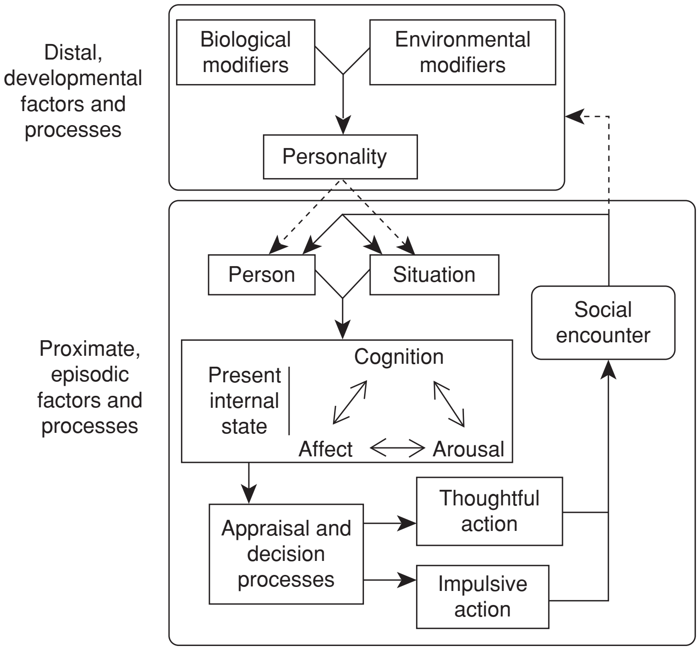



**Fig. 66.1** The General Aggression Model: Overall View.
Adapted from Anderson & Carnagey (2004) with permission of Elsevier.

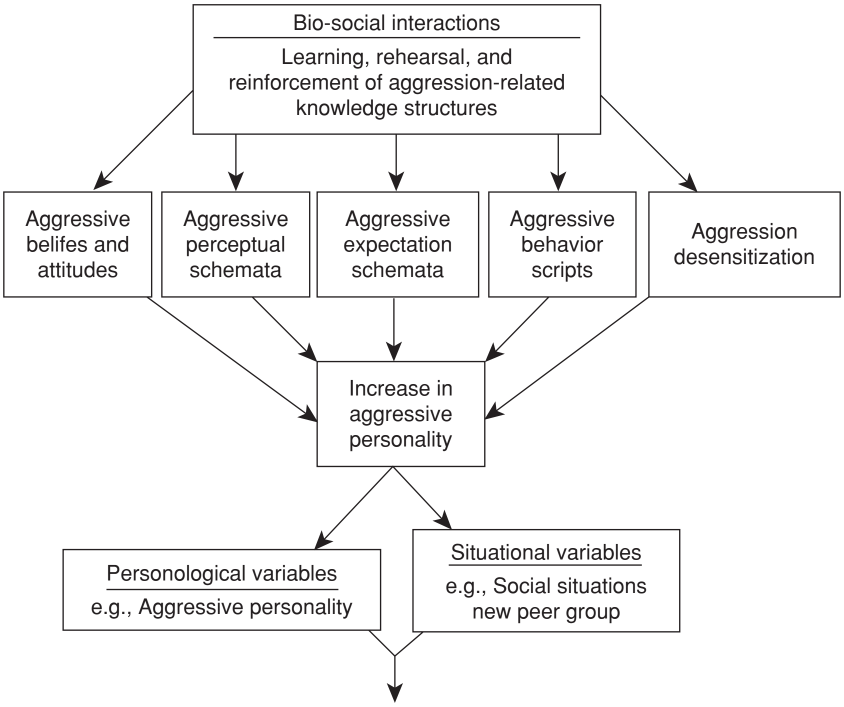



**Fig. 66.2** The General Aggression Model: Developmental and Personality Processes.
Adapted from Anderson & Carnagey (2004) with permission of Elsevier.

increase in aggressive personality as well as changes in situational variables including peer groups and social activities (Anderson & Bushman, 2002).

One of the fundamental predictions derived from the GAM is that short-term or long-term exposure to VGV should lead to changes in a constellation of thoughts and actions. Consistent with this prediction, meta-analyses demonstrate that exposure to VGV is associated with an increase in physical aggression, aggressive cognition, aggressive affect, and physiological arousal, and a decrease in helping behavior (Anderson et al., 2004). Furthermore, the magnitude of the effect of VGV on measures of aggression appears to be similar in experimental and cross-sectional studies. More recent longitudinal studies also find the expected relative increase in aggression over time in those who consume high levels of VGV (Anderson et al., 2008; Moller & Krahe, 2009; Wallenius & Pnamaki, 2008).

The robust effect of VGV on aggressive behavior, thought, and affect leads to the question of what factors may give rise to this effect. This question has been examined in two types of investigations. Some studies have examined the effect of various experimental manipulations (i.e., situational variables) on the magnitude of the violent video game effect while other studies have examined the influence of individual differences (i.e., personological variables) on the violent video game effect.

Studies examining situational variables have considered variation in characteristics of the games that are used to prime aggression. Based upon available evidence, the violent video game effect appears to be insensitive to the story line, the nature of the aggression (e.g., first person shooter, driving, and hand-to-hand combat), and the humanness of the target (Anderson et al., 2004; Bushman & Anderson, 2002). The level of aggression may also be similar for screen-based and more immersive technologies (Arriaga, Esteves, Carneiro, & Monteiro, 2008). There are, however, other characteristics of games that occasionally moderate the violent video game effect. For instance, the level of blood that is associated with in-game aggression moderates aggression both during and after game play (Barlett, Harris, & Bruey, 2008). The type of reinforcement that is associated with in-game aggression also seems to moderate the level of aggression (Carnagey & Anderson, 2005). Specifically, an increase in aggressive thoughts and actions is observed for individuals who are rewarded for violence during game play, but not for individuals who are punished for violence or play a nonviolent version of the game.

Furthermore, punishing violent actions within a game leads to a dramatic decrease in the number of such actions. Consistent with the GAM, the evidence from the two later studies indicates that positive reinforcement for aggression represents one source of violent video game effects.

Various individual difference and personality variables occasionally moderate or partially mediate the violent video game effect on aggression, though such cases are rare. For example, the violent video game effect is sometimes stronger for males than females (Bartholow & Anderson, 2002), although violent video games clearly lead to increased aggression in females (Anderson & Murphy, 2003). Trait aggression also occasionally moderates violent video game effects, but again such interactions are rare. Furthermore, when found in correlational studies, such moderation may be a methodological artifact because trait aggression is itself influenced by repeated exposure to VGV. A more consistent moderator variable is level of parental involvement in media use (Anderson et al., 2007). Children whose parents are highly involved in the child's media choices and use are less affected by VGV. This moderation effect was observed in a short-term experimental setting (Study 1), a cross-sectional analysis of trait aggression (Study 1), and a longitudinal study (Study 3; Anderson et al., 2007). The effect of trait aggression on VGV may be partially mediated by revenge motivation (Anderson et al., 2004; Bushman & Anderson, 2002) or the perception of hostility (Bartholow, Sestir, & Devic, 2005) that is experienced in response to provocation.

There is some evidence that individual differences in empathy may partially mediate the violent video game effect (Bartholow et al., 2005). The findings of this study are consistent with the GAM (Anderson & Bushman, 2002), as exposure to VGV would be expected to activate schemata that could bias the individual toward interpreting the actions or others as being more hostile and acting on this perceived threat in a more aggressive manner. Furthermore, evidence from a pair of studies demonstrates desensitization to real violence may be the locus of the influence of empathy on the VGV effect. In one experiment (Carnagey, Anderson, & Bushman, 2007), participants played either a violent or a nonviolent game and then viewed scenes of real violence while heart rate and skin conductance were measured. Those who played a nonviolent game experienced increases in heart rate and skin conductance while later viewing the real violence, whereas those who had played a violent game did not. A second experiment (Bushman & Anderson, 2008, Experiment 1) used the same basic experimental procedures but considered helping behavior directed towards the victim of a (staged) fight outside the lab room. Those who had played a violent game were less likely to provide help and took longer to help than those who had played a nonviolent game.

The findings of studies examining neural recruitment during video game play are also consistent with the GAM, and have generally revealed that playing video games activates neural networks associated with reward processing and addiction (Koepp et al., 1998; Mathiak & Weber, 2006). Significant activation of the orbitofrontal cortex was observed when individuals played a computer game that involved capturing territory from an opponent (Hoeft, Watson, Kesler, Bettinger, & Reiss, 2008). This region is often associated with the encoding of reward value. Males demonstrated greater activation in the orbitofrontal cortex and the mesocorticolimbic system, indicating that they may have found the competitive aspects of the game more rewarding than females. A second study found that dopamine levels were elevated during video game play and that this elevation was similar to that associated with the administration of amphetamine that is known to activate the reward system (Koepp et al., 1998). Studies using functional MRI also reveal what may be desensitization to violence. During violent video game play, the rostral anterior cingulate cortex and amygdala are deactivated (Mathiak & Weber, 2006), and these neural structures are known to be related to the evaluation of the emotional content of stimuli.

## *Cognitive Science*

### VISUOSPATIAL COGNITION

Evidence from a number of studies demonstrates that the same types of video games that lead to increased aggression can serve to enhance visuospatial cognition. This enhancement can be seen in individual differences between video game players (VGPs) and non-players (NVGPs; Green & Bavelier, 2003, 2007; Lintern & Kennedy, 1984; Yuji, 1996) and in NVGPs after as little as 10 hours of training (Dorval & Pepin, 1986; Green & Bavelier, 2006). This research has revealed improvements in several domains including hand-eye coordination (Griffith, Voloschin, Gibb, & Bailey, 1983), visual attention (Castel, Pratt, & Drummond, 2005; Green & Bavelier, 2003), and flight simulation (Lintern & Kennedy, 1984).

Early studies in this area of inquiry examined the utility of video games in training pilots. Two studies using the Atari video game *Air Combat Maneuvering* revealed that the game was useful for identifying military personnel who would be successful pilots (Jones, Kennedy, & Bittner, 1981). In a similar study, Gopher et al. (1994) compared the flight performance of Israeli Air Force cadets who had been trained on *Space Fortress II* and an untrained group. This study revealed that trained cadets performed better in almost all aspects of flight performance, resulting in the game being adopted as a part of the training program.

Green and Bavelier (2003) have systematically investigated the basis of the video game effect on visuospatial cognition. These authors have reported positive effects of video game experience in a number of tasks examining visual enumeration, the useful field of view, the attentional blink, multiple object tracking, and the spatial resolution of vision (Green & Bavelier, 2003, 2006, 2007). Together, the findings of these studies demonstrate that video game experience can enhance the spatial and temporal resolution of visuospatial cognition for both static and dynamic displays.

In a series of studies, Green and Bavelier (2006) have examined the locus of the video game effect on the span of apprehension, which reflects the number of stimuli that can be extracted from a brief exposure to a visual display. As measured in the visual enumeration task the span of apprehension is typically 1.5 items greater for VGPs relative to NVGPs. Foundational work by Trick and Pylyshyn (1993) reveals that the output of two processes (i.e., subitizing and counting) gives rise to the span of apprehension. Subitizing represents the rapid, relatively automatic, extraction of 1 to 3 items from a visual display; in contrast, counting represents a slow, resource demanding, process that supports the extraction of 4 or more items from a visual display. By examining differences in response time and accuracy in the visual enumeration task under different conditions, Green and Bavelier were able to determine that the limit of subitizing was similar in VGPs and NVGPs, and that counting was more efficient in VGPs relative to NVGPs. These findings indicate that the expansion of the span of apprehension results from an increase in the efficiency of resource demanding cognitive processes rather than an increase in the number of items that can be automatically extracted from a display (Green & Bavelier, 2006).

## EXECUTIVE FUNCTION AND COGNITIVE CONTROL

Evidence from a growing number of studies reveals that experience with the same types of games that produce benefits to visuospatial cognition may also be associated with disruptions of executive function or controlled attention. Two studies have reported that video game experience is positively correlated with attention deficits related to impulsivity and hyperactivity (Gentile, 2009; Swing, 2008). Gentile (2009) observed that adolescents reporting pathological video game consumption were 2.77 times more likely to be diagnosed with ADD or ADHD than were adolescents who reporting non-pathological video game consumption. Evidence reported by Swing (2008) replicates this basic finding and demonstrates that the relationship between video game experience and attention pathology remains significant even after controlling for the overall level of exposure to films and television, indicating that there is a unique effect of video game experience on attention.

Other work in this domain has focused on the relationship between video game experience and cognitive control in the Stroop task. Kronenberger et al. (2005) reported a moderate positive correlation between video game experience and the Stroop interference effect. Complimenting this finding, a study using fMRI found that VGPs failed to recruit anterior cingulate and lateral prefrontal cortex on incongruent trials during performance of the Stroop task, whereas these structures were recruited by low video game players (LVGs; Mathews, et al., 2005). This finding led to the suggestion that video game experience is associated with a disruption in the ability to engage the cognitive control network (Mathews et al., 2005).

A limitation of the study by Mathews et al. (2005) is that the task design makes it impossible to determine whether there is a general effect of video game experience on cognitive control or whether the influence is limited to specific control processes. We recently addressed this question using behavioral and event-related brain potential (ERPs) measures to examine the influence of video game experience on proactive and reactive cognitive control (Bailey, West, & Anderson, 2010). Proactive control represents a future-oriented form of control that serves to optimize task preparation; reactive control represents a just-in-time form of control that serves to resolve conflict within a trial (Braver, Gray, & Burgess, 2007). Bailey et al. found that the conflict adaptation effect (a behavioral measure of proactive control) was attenuated in HVGs relative to LVGs when there was a long delay between trials, and that this effect was associated with an attenuation of the medial frontal negativity and frontal slow wave (ERP indices of proactive control) in HVGs (Figure 66.3). In contrast, there was no difference between HVGs and LVGs for behavioral or neural indices of reactive control. These findings complement evidence revealing an association between attention deficits/hyperactivity and lead to the suggestion that video game experience may have a selective effect on proactive cognitive control processes that serve to maintain optimal goal-directed information processing. Of course, additional research using experimental and longitudinal designs is required to establish the causal nature of the effect of video game experience on cognitive control.

### *Affective Science*

Violent video games have been shown to increase aggression (Anderson & Bushman, 2001), but less is known about how VGV affects the processing of positively and negatively valenced stimuli. At the behavioral level, Kirsh and colleagues (Kirsh & Mounts, 2007; Kirsh, Mounts, & Olczak, 2006; Kirsh, Olczak, & Mounts, 2005) have reported an increase in the bias toward processing angry faces and a decrease in the bias toward processing positive faces associated with exposure to VGV and other violent media. These studies suggest that exposure to VGV may lead to alterations in the experience of both positive and negative affect.

### *Autonomic Measures*

One method of assessing the effects of video games on affect is to measure physiological arousal. Research has shown that playing video games can lead to an increase in arousal as measured by heart rate, blood pressure, and skin conductance (Arriaga, Esteves, Carniero, & Monteiro, 2006; Bushman & Huesmann, 2006; Schneider, Lang, Shin, & Bradley, 2004). As an example of this effect, Ballard and Weist (1996) reported an increase in heart rate in males while playing Mortal Kombat compared to playing a billiards video game. They also found that systolic blood pressure was increased in participants playing a more graphically violent level (i.e., more blood) of Mortal Kombat compared to a less graphically violent level or billiards. Increased arousal can be associated with greater aggression and hostility following exposure to VGV (Anderson & Bushman, 2001). However, VGV has been found to lead to an increase in aggressive behavior even when physiological arousal is equated in the violent and nonviolent video game conditions (Anderson et al., 2004). This finding is important as it indicates that increased arousal is not the cause of the VGV effect on aggression.

Several attributes of video games have been shown to influence physiological arousal. Increases in heart rate are observed after playing games with greater amounts of blood compared to the same game with less blood or no blood (Barlett, Harris, & Baldassaro, 2007). Using a light gun rather than a standard controller to play a video game also produces a greater increase in heart rate (Barlett et al., 2008). Similarly, the addition of virtual reality to the game increased heart rate compared to playing the same video game on a computer monitor, and this is true for both violent and nonviolent games (Arriaga et al., 2008). In an interesting study, Schneider et al. (2004) demonstrated that the

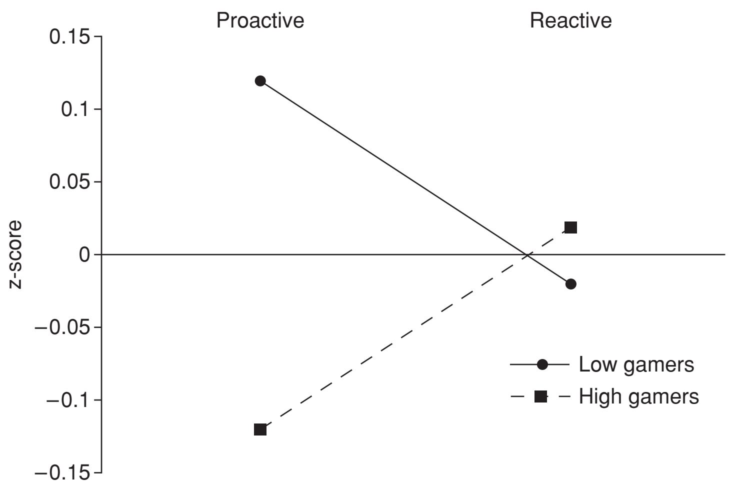



**Fig. 66.3** The effect video game experience and proactive, but not reactive, cognitive control collapsing across behavioral and ERP measures of these two type of control.
From Bailey et al. (2010) with permission of John Wiley and Sons.

presence of a storyline increased skin conductance levels in four different violent video games relative to the same games played without a storyline. Together, these findings lead to the suggestion that physiological arousal is influenced by the graphic and immersive nature of video games, as well as the violent content.

### *Cortical Measures*

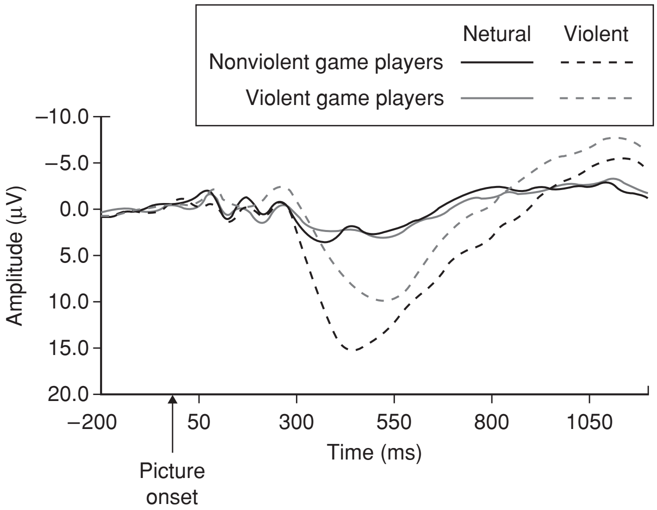
Two studies have examined the effects of VGV on the neural correlates of affective picture processing using ERPs. Bartholow, Bushman, and Sestir (2006) examined the influence of individual differences in exposure to VGV on the negativity bias. The negativity bias represents an enhanced positivity over the parietal region of the scalp associated with the processing of negative images relative to positive or neutral images that is thought to reflect an automatic orienting of attention to motivationally significant information in the environment (Ito, Larsen, Smith, & Cacioppo, 1998). Based on the GAM, Bartholow et al. (2006) predicted that the amplitude of the P3 (i.e., negativity bias) would be attenuated in VGPs relative to NVGPs for violent images, resulting from desensitization. In this study males viewed violent, negative nonviolent, and neutral images. As predicted, an increase in exposure to VGV was associated with a decrease in the amplitude of the P3 for violent images (Figure 66.4). In contrast, there was no effect of exposure to VGV on negative nonviolent images. Based upon these data the authors concluded that desensitization associated with exposure to VGV had a relatively selective effect on the processing of violent images.

In an extension of Bartholow et al. (2006), Bailey, West, and Anderson (2009b) examined the effects of individual differences in exposure to VGV on the processing of positive and negative pictures using ERPs. This comparison was motivated by work demonstrating that exposure to VGV influences the processing of both positive and threatening faces (Kirsh et al., 2006). In this study VGPs and NVGPs rated neutral, positive, negative nonviolent, and violent images on three dimensions (i.e., pleasantness, how threatening, and colorfulness; Bailey et al., 2009b). Consistent with the findings of Bartholow et al. (2006), the amplitude of the negativity bias was attenuated for violent images in VGPs relative to NVGPs. Comparison of the ERPs elicited by positive stimuli revealed a second interesting effect that reflected a modulation of the P3 in addition to slow wave activity over the occipital-parietal region of the scalp. In the pleasantness rating condition this effect distinguished positive images from neutral images in the NVGPs, and positive and violent images from neutral images in the VGPs. In contrast, in the threat rating condition this effect was not observed in either group. This finding is consistent with GAM and may indicate that exposure to VGV results violent and positive images taking on similar affective valence.

### *Education Science*

One application of video games that may produce positive outcomes for children is in educational settings. The popularity of this medium among young children and adolescents makes video games a prime vehicle for educational and health-related

**Fig. 66.4** The effect of video game violence on the amplitude of the P3 elicited by violent images, but not negative nonviolent images. Adapted from Bartholow et al. (2006) with permission of Elsevier.



messages. Video games may change behavior through the development of new skills and knowledge structures leading to the enhancement of self-efficacy (Baranowski et al., 2008; Lieberman, 2001). To date, research has investigated the utility of educational video games in the treatment of cancer (Beale, Kato, Marin-Bowling, Guthrie, & Cole, 2007; Kato & Beale, 2006), diabetes (Aoki et al., 2004; Brown et al., 1997), obesity (Lanningham-Foster et al., 2006), fetal alcohol syndrome (Padgett, Strickland, & Coles, 2006), and asthma (McPherson, Glazebrook, Forster, & Smith, 2006).

The management of childhood obesity is one promising area of investigation. Obesity has become a major health risk for many children in the United States. Active video games may be one way of combating this problem among children who prefer these media to traditional sports. Supporting this idea, one study found that the energy expended while playing games like *Dance Dance Revolution* is equivalent to that expended during physical activities like running and playing basketball (Straker & Abbott, 2007). Therefore, this evidence, coupled with the increasing popularity of physically interactive games like Wii Sports and Wii Fitness may represent a positive front in the battle against childhood obesity.

## Implications of Social and Cognitive Neuroscience

### *(De)sensitizaton and Video Games*

A curious aspect of the data reviewed in the previous sections is that exposure to VGV appears to result in desensitized responses in some contexts (Bartholow et al., 2006; Carnagey et al., 2007) and sensitized responses in other contexts (Kirsh et al., 2006). These findings lead to the natural question of how opposite effects may arise from the same set of experiences. An answer to this question may be found in a consideration of the influence of VGV on the neural systems that are likely recruited in the service of these tasks.

A number of studies examining the neural basis of affective information processing have revealed a modulation of the ERPs (i.e., early posterior negativity or EPN) over the occipital region of the scalp beginning around 250 ms after stimulus onset that is elicited by pictures of stimuli that are "high in evolutionary significance" (e.g., erotica and mutilations) (Junghöfer, Bradley, Elbert, & Lang, 2001; Schupp, Junghöfer, Weike, & Hamm, 2003). Most relevant to the current discussion, the amplitude of the EPN is greater for images of threatening faces than for images of neutral or friendly faces (Schupp, et al., 2004). In contrast, threat did not appear to influence the amplitude of the N170 (Schupp et al., 2004) that reflects a relatively early stage of face processing supported by the fusiform gyrus. Based on this finding it may be that the increased sensitivity to threatening faces associated with VGV results from enhanced processing of facial features in higher-level visual areas that occurs shortly after identification of the stimulus as a face. The adaptive benefit of this effect becomes clear within the context of first person shooter games where the rapid discrimination between friend and foe has significant survival value.

Based on data published by Bartholow et al. (2006) it appears the effects of desensitization emerge at a stage of information processing that is later than is reflected by the EPN. Specifically, Bartholow observed that the amplitude of the P3 component was attenuated in HVGs relative to LVGs. The cognitive processes reflected by the P3 have been intensively studied over the last 30 years (Polich, 2007). The P3 is commonly thought to arise from the engagement of neural processes associated with the allocation of attentional or mental resources to stimulus processing during motivated decision-making processes (Duncan-Johnson & Donchin, 1977) that involve dopaminergic modulation of the locus coeruleus-norepinephrine system (Nieuwenhuis ~~et al., 2004~~). Based on these ideas related to the origin of the P3 component it may be that the desensitizing effect of VGV on the processing of violent images results from a reduction in the allocation of attention or a decrease in the degree that these stimuli are deemed motivationally significant (Cacioppo et al., 1994; Ito et al., 1998). Furthermore, together the evidence reviewed in this and the previous paragraphs leads to the suggestion that VGV may be associated with the enhancement of relatively early processing of threatening stimuli supported by visual association areas, and a reduction in activation of higher cortical areas associated with decision making.

### *Attention Deficit/Hyperactivity*

From a public health perspective, one of the more alarming observations emerging from the literature is the relationship between video game experience and ADHD. At an anecdotal level, parents of children with ADHD often report that one of the few activities their child can engage in for an extended period of time is playing video games. Several recent findings may call the wisdom of this practice into question. Bioulac, Arfi, and Bouvard (2008) found that children with ADHD who also reported problem video game playing demonstrated higher levels of disorder-related symptoms, and higher levels of delinquency and aggression. Consistent with this finding, Gentile (2009) found that 8–18 year olds with pathological video game habits reported a higher incidence of diagnosis with ADD or ADHD, greater difficulty paying attention at school, and lower grades. Also, recent work by Swing (2008) indicates that there may be an interaction between nonpathological variation in impulsivity and hyperactivity and video game experience when predicting grade point average. Together these findings reveal what appears to be a nontrivial relationship between video game experience and disorders of attention.

How might the confluence of video game experience and ADHD be understood within the context of what is known about the cognitive neuroscience of these two domains? As described earlier, exposure to violent video games may be associated with a disruption in the ability to recruit neural structures that support proactive cognitive control (Bailey et al., 2010). Disruption in the recruitment of these same structures is often implicated in the behavioral pathology of individuals with ADHD (Barkley, 1997; Nigg & Casey, 2005) and conduct disorders (Kronenberger et al., 2005; Mathews et al., 2005). Together these findings lead to the suggestion that ADHD in combination with high levels of video game experience may have a negative synergistic effect on the neural architecture that supports cognitive control and self-regulation. Importantly, other recent evidence demonstrates that playing strategy-based video games may lead to enhancements in cognitive control (Basak, Boot, Voss, & Kramer, 2008). This finding then leads to the suggestion that directing individuals toward games that exercise specific executive processes could in fact lessen, rather than magnify, the effects of ADHD.

## Conclusions

Here we have reviewed the literature examining the effects of video game experience in the domains of social, cognitive, affective, and education science. This literature reveals some paradoxical effects wherein experience with the same types of games can lead to an increase in aggression, a decrease in cognitive control, and an increase in visuospatial abilities. A consideration of the behavioral, neuroanatomical, and physiological bases of the effects of video games leads to the suggestion that exposure to these media is associated with plasticity within neural networks supporting high level vision, emotion processing, cognitive control, and social decision making. Future investigations focusing on within and between domain comparisons using behavioral and neuromonitoring techniques are likely to provide greater insight into the neural basis of the effects of video games.

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