The Multiple Dimensions of Video Game Effects

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ABSTRACT—***Video games are at the center of a debate over what is helpful or harmful to children and adolescents, and there is research to substantiate both sides. The existing research suggests that there are at least 5 dimensions on which video games can affect players: the* amount *of play, the* content *of play, the game* context*, the* structure *of the game, and the* mechanics *of game play. This article describes each of these 5 dimensions with support from the scientific literature, arguing that this approach can allow people to get beyond the typical "good–bad" dichotomous thinking to have a more nuanced understanding of video game effects and to provide testable hypotheses for future research.***

KEYWORDS—*video games; media effects; dimensional approach*

In the past 30 years, digital electronic games (hereafter called video games) have gone from novelty entertainment to one of the largest industries in terms of both money (posting more than $21 billion in sales in 2008 and growing 19% despite the poor global economy) and audience reached, with 92% of American children playing video games (Gentile & Walsh, 2002) and the "average" gamer being 35 years old (ESA, 2008). As with any new medium, video games have come under fire from critics about potential harms, and also have been praised for potential benefits. Not surprisingly, the rhetoric this "debate" engenders generates more heat than illumination. Two examples demonstrate this.

One of the most vocal critics has been a now-disbarred lawyer, Jack Thompson, who routinely assumed that most high-profile violent crimes, such as school shootings, stemmed in part from violent game play. In a public letter to the mother of the CEO of a video game company, he wrote,

> . . . the recent plethora of cop killings is caused in part by your darling son's entrepreneurial energy. There are three policemen dead in Alabama because of Grand Theft Auto. I was on 60 Minutes about it. I hope [your son] has provided you with a flat screen TV to see the grief of the bereaved families that fills the screen. (Cavalli, 2008)

On the opposite side, the video game industry has also sometimes misrepresented the issues. The president of the Entertainment Software Association said in a televised 2004 interview,

> Every researcher who's come to this without a preconceived notion trying to prove that video games are harmful has looked at the literature and said that there is absolutely no evidence to suggest that violent video games are harmful. (Palmer, 2004)

Educators have long recognized the potential of software and games to teach. The 1980s saw a push to get computers into the classroom, and schools adopted early educational games such as *Oregon Trail* to help teach schoolchildren about geography and pioneer life. Indeed, games do many things that are excellent pedagogy (Gee, 2003, 2005; Gentile & Gentile, 2008). They are motivating, provide immediate feedback, can adapt themselves to the level of the learner, provide repetition to the point of automaticity, encourage distributed learning, can teach for transfer, and use other excellent teaching techniques.

Ironically, both sides are usually correct about the effects games can have. They tend, however, to select different research literatures to make their points. The problem for parents, educators, game producers, policymakers, and researchers is that the polarizing rhetoric is damaging and ultimately misses the point. Video games are neither "good" nor "bad."

The existing research suggests that there are at least five dimensions on which video games can affect players: the *amount* of play, the *content* of play, the game *context*, the *structure* of the game, and the *mechanics* of game play. Although future studies may demonstrate additional dimensions, these five appear able

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to account for the effects documented in the existing research literature. My discussion here focuses on each as a main effect; it is likely that the dimensions interact with each other, but the focus of this article is to describe each theoretically distinct dimension.

AMOUNT OF GAME PLAY

Many studies have found associations between the amount of game play and several negative outcomes, such as increased aggression. It is likely, however, that some of these associations are not due to amount per se, but are artifacts of the relation between amount and the other dimensions. If gamers spend no time playing, no effects can happen. Furthermore, greater amounts of time imply increased repetition of other game aspects, so amount of play likely influences the magnitude of other effects. Independently, total amount of game time appears to be related to school performance, risk of obesity, and other physical health outcomes. For example, Figure 1 shows that when we separate amount of video game play from violent game content, it directly predicts poorer school performance but not increased aggressive behavior, whereas violent content directly predicts aggressive behavior but not school performance (Anderson, Gentile, & Buckley, 2007; Gentile, Lynch, Linder, & Walsh, 2004). Most researchers suggest the displacement hypothesis, that games displace time on other activities, as an explanation. It is possible to argue that this relation might be due to the children themselves, rather than to game time. It is likely that children who perform more poorly at school are likely to spend more time playing games, where they may feel a sense of mastery that eludes them at school. Nevertheless, each hour a child spends playing entertainment games is an hour not spent on homework, reading, exploring, creating, or other things that might have more educational benefit. Therefore, although children may initially seek games because they are poor students, large amounts of play are likely to hurt their grades further. In fact, Figure 1 suggests this effect, as amount of video game play early in a school year negatively predicted school performance later in the school year.

Studies have also demonstrated an association between the amount of time spent on games and other screen media and the risk of childhood obesity (Berkey et al., 2000; Laurson et al., 2008; Vandewater, Shim, & Caplovitz, 2004). Several mechanisms have been proposed, including the displacement of physical activity or the increased eating of high-fat, high-sugar foods. However, the new trend in video games to movement-based games (such as *Dance Dance Revolution*, the Nintendo Wii) may ultimately reverse this effect for children who play those types of games.

Other health issues have also been linked to amount of game play. There are cases of children reporting repetitive stress injuries due to overuse of game controllers. There is even a thumb injury called "Nintendinitis" (Brasington, 1990). Total amount of play has also been linked to pathological gaming, colloquially called video game "addiction" (Charlton, 2002; Chiu, Lee, & Huang, 2004; Fisher, 1994; Gentile, 2009; Gentile et al., 2011; Griffiths & Hunt, 1998; Johansson & Gotestam, 2004; Yee, 2001). The research on pathological

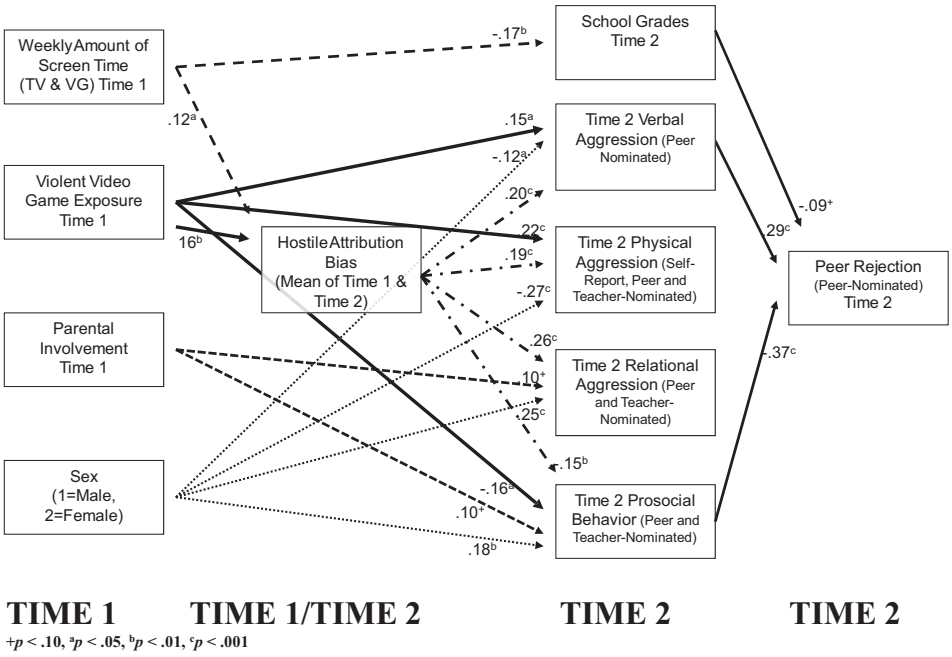

Figure 1. Longitudinal path analysis demonstrating direct effects of the amount of screen time and violent game exposure (adapted from Anderson et al., 2007).

gaming is still young, but it is likely that although amount may turn out to be a necessary factor, it cannot be a sufficient factor (Gentile, 2009).

How the amount is spent may also matter. Educators know that distributing practice over time is better for long-term learning than putting in a lot of time all at once, known as massed practice (Anderson, 1983). In one study among gamers playing equal amounts of violent games, those who split their play into more regular and frequent intervals were more likely to become aggressive than those who distributed their play less (Gentile & Gentile, 2008). Thus, how gamers distribute their amount of play may matter over and above simply how much they play.

CONTENT OF GAME PLAY

There is no standard definition of *content*, although most definitions would likely focus on the script elements or themes of the game. For example, a game in which the "script" included requiring the player to solve math puzzles would likely provide educational math content, whereas a game in which the script for the characters included shooting at each other would provide violent content. There are now dozens of studies of the short-term and long-term effects of violent video game, including experimental studies that demonstrate causal effects (Anderson & Dill, 2000; Anderson et al., 2007; Ballard & Wiest, 1996; Bushman & Anderson, 2002), correlational studies that demonstrate real-world associations (Anderson & Dill, 2000; Anderson et al., 2007; Bartholow, Bushman, & Sestir, 2006; Gentile et al., 2004; Krahe & Moller, 2004; Wiegman & van Schie, 1998), and longitudinal studies that demonstrate effects accumulating across time (Anderson et al., 2007; Anderson et al., 2008; Hopf, Huber, & Weiss, 2008; Moeller & Krahe, 2009; Wallenius & Punamäki, 2008). Meta-analyses demonstrate that playing violent games increases aggressive cognitions, aggressive feelings, and aggressive behaviors (Anderson, 2004). Although several theories posit mechanisms for this effect, most suggest that the violent content primes aggressive concepts. Conversely, if games include prosocial content where characters help each other in nonviolent ways, then this should predict prosocial behavior in both the short term and the long term, which studies have also demonstrated (Gentile et al., 2009).

Many educational games teach specific skills, such as reading or math. Meta-analyses demonstrate that although some are more successful than others, educational games are very good at teaching their content (Murphy et al., 2002). Some games have been designed to teach health knowledge and skills. For example, young cancer patients who played a video game designed to teach about cancer and treatment learned more than patients who played an entertainment video game instead (Beale, Kato, Marin-Bowling, Guthrie, & Cole, 2007). In addition, these patients were better at regular adherence to taking prophylactic antibiotics (Kato, Cole, Bradlyn, & Pollack, 2008). Other studies have used games designed to teach children to recognize symptoms and take care of their asthma or diabetes. In general, research has found these games to have a greater effect on children's healthcare compliance behaviors than giving the children pamphlets with the same information (Lieberman, 1997, 2001a, 2001b). Overall, it is clear that children learn game content, and this learning (as with all learning) can affect future behaviors.

GAME CONTEXT

The least researched dimension of game effects is how the game context alters or creates effects. Context is also the least well defined, but we can describe several aspects. First, changing the rules or goals of a game is a type of in-game context that could moderate the effects. For example, one can play a version of "capture the flag" in the violent game *Halo* with other players. In one context, players form teams and attempt to shoot the other team's players in order to capture the flag. In another context, players can play in "slayer" mode, where they shoot any other player. Both contexts could expose the player to the same amount of game violence, but the effects might be different. It might be that the "everyone for himself" approach leads to greater increases in aggressive thoughts, lower empathy, and greater desensitization than when one plays as part of a team. No studies have examined this, but it is a viable hypothesis, and research on television and movie context effects support it.

Similarly, the social context in games might moderate the effects. For example, in massively multiplayer online (MMO) games such as *World of Warcraft*, one can play with thousands of other players. In these games, cliques form, either informally or formally within the game (sometimes called joining a "guild"). Many of the game goals require multiple people to complete. This provides a social context for the game content. Therefore, if one is playing a game segment that requires violence to complete, the social context could moderate the effect. It could be that it enhances the violence effect, because one receives social support from people one considers friends while behaving aggressively in the game. It could be, however, that it mitigates the effect, if one's motivations are altered such that the player focuses on prosocial motivations to help one's teammates, rather than focusing on aggressive motivations. Although both of these are reasonable hypotheses, no studies have yet been conducted to test them.

As I noted earlier, although each of the dimensions I describe here is theoretically independent, it is likely that they interact with each other during game play. In many games, the game context can influence the game content, as players may experience different script elements based on the decisions they make in the game. The *World of Warcraft* example demonstrates this, as a player who plays in a guild with other players will have access to game content that a solo player will not.

In addition to moderating other effects, such as content effects, teamwork as a contextual variable may have direct effects on

collaboration and cooperation skills. For example, two studies of a virtual game environment designed to encourage teamwork and cooperative working methods among vocational students found that the game did encourage collaboration (Hämäläinen, 2008; Hämäläinen, Manninen, Järvela, & Häkkinen, 2006).

Another context aspect that may have independent effects is how the game provides contextual clues to in-game problem solving. For example, one study of problem-solving skills used when encountering impasses while playing a novel game asked frequent and infrequent gamers to think aloud while playing (Blumberg, Rosenthal, & Randall, 2008). Frequent gamers made significantly more references to using insight to resolve the impasse and to specific game strategies to achieve specific goals. Furthermore, the complexity of many games means that they have the potential to promote complex problem-solving strategies. In a study of postings on in-game MMO bulletin boards, 86% of posts focused on the development of understanding through social knowledge construction, including collaboratively solving problems, argumentation using evidence, and the presentation of counter-arguments (Steinkuehler & Duncan, 2008). In addition, many posts included detailed scientific and mathematical models to explain game features. Thus, the game context creates an environment that fosters and models informal scientific reasoning practices. To date, however, there seems to be more written about the potential for game contexts to affect problem-solving skills than there are studies testing it (de Freitas & Griffiths, 2007; Ravenscroft, 2007; Steinkuehler, 2008).

GAME STRUCTURE

Games require that players get information from a screen display. The screen displays are therefore carefully structured to provide meaningful information. At one level, this is similar to what communication scholars call "formal features" to describe how structuring information on the screen affects the psychological meaning (Huston & Wright, 1994). For example, if a couple enter a bedroom and shut the door, and it *fades* to black, we take away a very specific meaning about what happened behind that door. If, however, we see the same couple shut the door and it *cuts* to the next scene, we do not assume the same thing. In both cases, the content is identical, but the way it is structured changes the psychological meaning. Therefore, the structure of games could have independent effects on players.

It is possible to improve perceptual skills through practice, and these improvements should theoretically be specific to the types of structural information that is perceived. Several studies have now demonstrated that experience with video games can improve certain types of visual attention skills. One line of research has focused on how "action" video games (generally violent games, in which things could jump out and attack you) can improve visual attention to the periphery of a video screen (Green & Bavelier, 2003, 2006a, 2006b, 2007; Greenfield, DeWinstanley, Kilpatrick, & Kaye, 1994). This seems intuitively reasonable. In an action video game, the player needs to constantly be scanning the full screen because an enemy could pop out from anywhere, so the player needs to be able to detect small changes in color or texture in the periphery and react quickly. This seems similar to the type of skill an air traffic controller needs.

Many games require the player to navigate through a three-dimensional (3D) virtual world, although all the information for navigation is represented on a two-dimensional (2D) screen. Practice with these types of games should improve 2D to 3D transfer skills (Greenfield, Brannon, & Lohr, 1994). These types of games could also improve navigation, place-learning, and way-finding skills (Cánovas, Espínola, Iribarne, & Cimadevilla, 2008). Because many games require players to maintain awareness of orientation of the virtual world or of objects in it, it is also likely that these games can improve mental rotation skills (Cherney, 2008; Okagaki & Frensch, 1994; Sims & Mayer, 2002).

This does not exhaust the possible structural aspects that games include nor the perceptual and spatial cognitive skills that they could affect, and additional research will find more. One additional aspect deserves mention, however. Theoretically, when attempting to teach for transfer with a simulation, realism can greatly enhance learning and transfer. Therefore, as the screen representations become more realistic, all of the effects are likely to be enhanced.

GAME MECHANICS

Video games require the player to work with some type of controller. This could be a mouse and keyboard, a game control pad, a balance board, a joystick, and so on. At the simplest level, practice with any of these devices should improve skills with it. These could increase fine motor skills (such as with a thumb controller), gross motor skills (swinging the Wii remote like a baseball bat), or even balance skills (with the Wii balance board). Sometimes these effects are used intentionally, such as for physical therapy (Deutsch, Borbely, Filler, Huhn, & Guarrera-Bowlby, 2008) or to improve dynamic balance control after brain surgery (Betker, Szturm, Moussavi, & Nett, 2006).

Similar to the argument with game structure, we should expect greater transfer (and perhaps faster learning also) if the mechanics are more realistic. For example, we would expect greater transfer to one's real-world driving if one plays racing games with a wheel and pedals than if one plays with a mouse and keyboard. Other design factors might also be relevant, as some controller designs may be easier to learn or use than others (Hutchins, Hollan, & Norman, 1985; Still & Dark, 2008).

Finally, it is important to realize that although game mechanics and structure are theoretically distinct, they are not independent in practice. There is a continuous feedback loop between the two. What players see on the screen directs how they use the mechanical game controller. Many motions on the game controller result in changes on the screen, which results in changes to

the game controller, and so on. This is analogous to how perceiver motion allows for the detection of new perceptual information and the discovery of new affordances (Gibson, 1979). This visually guided motion, colloquially called "hand–eye coordination," is a skill that also can improve with practice.

Although the structure and mechanics dimensions can seem esoteric, they help to explain some video game effects that are not easily understandable otherwise. For example, in a study of laparoscopic surgeons, who perform surgery from outside the patient's body while looking at a screen, those who had played video games in the past for at least 3 hr a week were 27% faster and made 37% fewer errors on advanced surgical skills (Rosser et al., 2007). In fact, video game experience was a better predictor of surgical skill than prior laparoscopic surgical experience and years of practice. It is impossible to explain this result as a content effect, as the surgeons were playing normal video games and not surgical simulators, nor can we explain it solely as an amount effect or as a context effect. We can, however, explain it with structure and mechanics effects. Laparoscopic surgeons need to get 3D information from a 2D screen, they need to maintain spatial awareness and attention to all the information on the screen, and they need to be able to make fine motor adjustments on the basis of what they see. It is important to note, however, that this was a correlational study and thus cannot determine causality, although other studies have demonstrated that video games can causally train skilled behaviors (Gopher, Weil, & Bareket, 1994).

CONCLUSION

Digital games are routinely vilified or praised. Critics often cite the research on the effects of violent video games, whereas proponents often cite the research on perceptual skills. The irony is that both the critics and proponents are correct about the effects that games can have. The flaw is that they extend their arguments to conclude that video games are ultimately harmful or beneficial. Recognizing that games have effects on multiple dimensions allows us a way out of this dichotomous thinking. In fact, the same game can have both perceived positive and negative effects at the same time. For example, consider a hypothetical situation where a 12-year-old boy spends a lot of time playing the violent game *Grand Theft Auto*:

- Because he spends a lot of time playing, we might predict poorer school performance.
- Because of the violent content, we might predict increased aggressive thoughts, feelings, and, ultimately, behaviors.
- If he plays with other friends online, this might enhance (or mitigate) the violence effect and could train teamwork skills.
- Because it is both a shooting and driving game, we might predict improved 2D to 3D transfer skills and improved visual attention skills.
- If he plays with a joystick, we might predict improved joystick skills (and perhaps improved hand–eye coordination).

Therefore, the simplistic dichotomy of games being "good" or "bad" applies only to the extent that one focuses solely on a specific dimension of a particular game.

Two additional benefits of this approach are that it provides testable hypotheses and that it can inform game and instructional technology designers. To have the greatest effects, game designers should consider each of these dimensions when creating games. It is hoped that this dimensional approach will be of value to game designers, researchers, and the public discourse on game effects.

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