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ORIGINAL ARTICLE

The Effects of Technological Advancement and Violent Content in Video Games on Players' Feelings of Presence, Involvement, Physiological Arousal, and Aggression

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The possible impact of technological advancement on video games' effects—particularly in the case of violent games—has often been discussed but has not been thoroughly explored by empirical research. The present investigation employed a 2 3 2 between-subjects factorial experiment to examine the interplay of technological advancement and violence by exposing participants (N = 120) to either a newer or older version of a violent or nonviolent game and measuring these factors' effects on players' sense of presence, involvement, physiological arousal (measured by skin conductance), self-reported arousal, and affective and cognitive aggression. The results indicate that technological advancement increased participants' sense of presence, involvement, and physiological and self-reported arousal. Neither advancement nor violence had statistically significant effects on accessibility of players' aggressive thoughts, but there is some tentative evidence that violent game content increased players' state hostility. Theoretical and practical implications of findings are discussed, and recommendations are made for future research.

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Concern about the possible negative effects of violent video games has been accompanied by a boom in research, as is evident from meta-analyses identifying dozens of existing research reports, published over a period of more than 20 years, investigating the relationship between video games and aggression (Anderson, 2004; Anderson & Bushman, 2001; Sherry, 2001). Some scholars claim that enough evidence exists to conclusively link violent video games to real-life aggression (e.g., Bushman & Anderson, 2002), but others maintain that there is not sufficient support to establish a causal link between violent video game play and player aggression (e.g., Griffiths, 1999; Scott, 1995; Williams & Skoric, 2005).

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One major issue frustrating reconciliation of the clouded body of research on violent video game play is the vast advancement in video game technology that has occurred over the years. Researchers agree that video games are advancing and changing rapidly (e.g., Calvert & Tan, 1994; Sherry, 2001; Tamborini et al., 2004) and that new games provide increasingly realistic play (Carnagey & Anderson, 2004; Gentile & Anderson, 2003). Scholars have also speculated that such advances in game technology may precipitate more dramatic negative effects. Bensley and van Eenwyk (2001), for example, conclude in their interpretive literature review that existing research evidence does not convincingly indicate effects of video game play on real-world violence, but add that more compelling support for such an effect might be found by research on ‘‘more recent and increasingly realistic games’’ (p. 256).

Although some studies have examined the effects of advances in video game content, such as whether a game is accompanied by a narrative storyline (e.g., Schneider, Lang, Shin, & Bradley, 2004), existing experimental research has not detailed the role of technological advancement in video games’ effects on players. In response to concern about technological advancement possibly heightening negative effects of violent games, it is also necessary to study the effects of technological advancement in concert with those of violent content to investigate the interplay between these two video game dimensions (see Bensley & van Eenwyk, 2001).

The present study attempts to make a modest contribution to research on both video game effects and technological variables by examining the psychological effects of technological advancement in violent and nonviolent games. Specifically, we report results from a factorial experiment that manipulates both technological advancement and violent content to explore how they influence players’ sense of presence, involvement, arousal, and aggressive thoughts and feelings. In the following sections, we review relevant literature, propose hypotheses, and detail the methods of an experiment designed to test the hypotheses. After discussing the experiment’s results, we conclude by pointing out implications, limitations, and directions for future research.

Literature review

Technological advancement in video games

As media have become increasingly advanced, technological dimensions have grown increasingly pertinent to an understanding of media effects (see Eveland, 2003; Mundorf & Laird, 2002; Reeves & Nass, 1996). The role of technological advancements in a user’s experience of video games similarly merits exploration to further our understanding of the medium’s psychological and social impact. Schneider et al. (2004) conclude that ‘‘it is probably unwarranted to generalize the findings of video game research in the 80s and early 90s to the modern experience’’ (p. 362). Calvert and Tan (1994), Bensley and van Eenwyk, (2001), and Tamborini et al. (2004) express concern over the potential negative effects of increasingly advanced violent video games. Sherry (2001) reports a correlation between the effect size of violent video game play on aggression and a study's publication year ($r = .39$) and suggests that increased effects of newer and ''more graphic'' (p. 424) games on aggression might explain this trend. Although one study (Tamborini et al., 2004) found no significant differences between the effects of a virtual reality game and a traditional console game on players' hostile thoughts, the effects of advancement within traditional video game–play formats remain relatively unexplored.

In the absence of numerous studies specifically investigating the effects of video game advancement, research exploring the impact of technological form variables in other media can inform the present research (see Detenber, Simons, & Reiss, 2000). For example, increased interactivity (Sundar, Kalyanaraman, & Brown, 2003), animation (e.g., Lang, Borse, Wise, & David, 2002; Li & Bukovac, 1999; Sundar & Kalyanaraman, 2004), and download speed (Sundar & Wagner, 2002) have all been found to impact the effects of Web content on users. Similarly, increased audio and visual fidelity affects responses to film and television (Bracken, 2005; Reeves & Nass, 1996). The present research focuses on video game advancement's potential effects on three experience dimensions that have received particular attention in similar research on other media: presence, involvement, and physiological arousal.

Presence

One important media experience dimension often linked to technological advancement is presence. Presence has been defined as the ''perceptual illusion of nonmediation'' (Lombard & Ditton, 1997) and ''a psychological state in which virtual (para-authentic or artificial) objects are experienced as actual objects in either sensory or nonsensory ways'' (Lee, 2004, p. 37). In other words, presence describes a media user's feeling that mediated representations are real. The presence experience is highly relevant to video game players' mediated interaction with an engrossing and interactive virtual environment (Lee, 2004). Some potential effects of presence identified by Lombard and Ditton include enjoyment, improved task completion efficiency, and increased tendency to respond socially to media, so the implications of advancements' effects on presence in video game players could be substantial.

Steuer's (1992) selection of vividness as a key determinant of presence suggests a causal relationship between technological advancement in video games and feelings of presence in their players. Steuer describes vividness as ''the ability of a technology to create a sensorially rich mediated environment'' (p. 80) composed of sensory breadth, or the number of sensory channels provided, and sensory depth, or ''the resolution within each of these perceptual channels'' (p. 81). Vividness has been found to increase feelings of presence and positive attitudes when used in studies dealing with Web marketing (Coyle & Thorson, 2001; Li, Daugherty, & Biocca, 2002). Other media presentation features conceptually related to vividness, such as television image quality (Bracken, 2005) and screen size (Lombard, Reich, Grabe, Campanella, & Ditton, 2000), have also been found to increase feelings of presence. Newer games feature more realistic and vivid representations, suggesting that advancements in video game technology may similarly contribute to a higher sense of presence in players.

H1: Newer video games will induce higher levels of presence in game players than will older games.

Involvement

Witmer and Singer (1998) propose that involvement, which they describe as ''a psychological state experienced as a consequence of focusing one's energy and attention on a coherent set of stimuli or meaningfully related activities and events'' (p. 227) is closely related to presence. It should be noted that this conceptualization of involvement pertains only to the intensity of a user's engagement with a stimulus, unlike some conceptualizations in other contexts that extend the involvement concept to include antecedents to the user's experience with a stimulus (e.g., motivation) or consequences thereof (e.g., message evaluation outcomes) (see Andrews, Durvasula, & Akhter, 1990; Petty, Cacioppo, & Goldman, 1981; Petty, Cacioppo, & Schumann, 1983; Slater, 1997). Technological advancements in other media, such as the World Wide Web (e.g., Kalyanaraman & Sundar, 2006; Li et al., 2002), have been found to increase users' involvement with these media, suggesting that technological advancements in video games may also enhance users' involvement while playing video games (see Tamborini et al., 2004).

H2: Newer video games will make players feel more involved than will older games.

Arousal

Increased technological sophistication in media has also been linked to increased physiological arousal. Experiments involving video presentations have found both screen size (Lombard et al., 2000; Reeves, Lang, Kim, & Tatar, 1999) and motion (Detenber, Simons, & Bennett, 1998) to increase physiological arousal. In new media research, animation in Web advertisements has been found to increase physiological arousal (see Sundar & Kalyanaraman, 2004). Lombard and Ditton (1997) also consider arousal to be closely related to presence. In observing the effects of a narrative video game storyline on players' feelings of presence, Schneider et al. (2004) found a corresponding increase in physiological arousal. These findings suggest that technological advancement in video games may increase players' arousal as well.

H3: Newer video games will induce higher levels of physiological arousal in game players than will older games.

Video games and aggression

According to some models of video games' effects on aggression, advancement in video games may have negative implications as well (see Gentile & Anderson, 2003). Of several theoretical approaches that inform the possible effects of video game violence on aggression (see Sherry, 2001), those concerned with immediate effects of video game play on psychological states (as opposed to models of long-term effects) tend to focus on three psychological routes by which game violence may affect players: increased arousal, increased aggressive thoughts, and increased aggressive feelings.

The general aggression model

A number of theoretical frameworks dealing with such routes have been incorporated into the general aggression model (GAM), which details the possible effects of violent video game play on aggression (see Bushman & Anderson, 2002). According to the GAM's model of an aggressive episode, preexisting personal factors (such as personality traits) and situational factors (such as an incentive for aggressive action) influence aggressive behaviors. Finally, the results of these behaviors cyclically influence personal and situational factors that contribute to the repetition of the process in the future.

The impact of personal and situational ''input variables'' on aggressive outcomes, however, is indirect in that it is mediated by the cognitive, affective, and arousal states induced by dispositional and situational input variables. These psychological states may include, for example, increased accessibility of aggressive thoughts (cognitive), increased anger (affective), or heightened physiological activity (arousal). Effects of violent video games on each of these key psychological states have been observed in some studies (see Anderson & Bushman, 2001; Dill & Dill, 1998), though such effects remain disputed (see Bensley & van Eenwyk, 2001; Griffiths, 1999; Williams & Skoric, 2005). A discussion of theoretical frameworks and findings pertaining to video games' effects on each of these three psychological states is presented below.

Arousal

Zillmann's (1971) excitation transfer framework posits that arousal instantiated by exposure to exciting media content may be transferred to subsequent experiences intensifying emotional responses to those experiences. Although this residual arousal from earlier media exposure gradually dissipates with passage of time, it can intensify responses to later experiences even if the experiences are unrelated and the emotional response intensified is different than that evoked by the initial arousing experience. Although many stimuli can be arousing, violent content has received special attention as a generator of arousal in consumers (Sparks & Sparks, 2002). Anderson and Dill (2000) and Bushman (1995) also assert that violent movies and video games tend to be more exciting and conducive to arousal.

> H4: Violent video games will induce higher levels of physiological arousal in game players than will nonviolent games.

Considering the effects of both advancement and violence on arousal, the effects of violent content on arousal may be uniquely pronounced with advanced violent games because the effects of technological advancement enhance the effects of violent content to produce a synergistically heightened state of arousal.

> H5: Violent content's effect on arousal will be qualified by advancement, with advancement causing a greater increase in arousal for violent games than for nonviolent games.

Aggressive thoughts

According to priming effects (e.g., Berkowitz & Rogers, 1986), exposure to a stimulus with a particular meaning increases accessibility of related thoughts, feelings, and behaviors, which may affect responses to subsequent stimuli (Roskos-Ewoldsen, Roskos-Ewoldsen, & Dillman Carpentier, 2002). Priming predicts that exposure to violent media leads to more rapid identification of aggressive constructs in the minds of message recipients (Bushman, 1998). When compared to players of a nonviolent game, players of a violent game have been found to identify aggressive words relatively more quickly than nonaggressive words (Anderson & Dill, 2000) and include more aggressive outcomes when asked to complete an unfinished story stem that involves a potential conflict situation (Bushman & Anderson, 2002). Meta-analyses assessing experimental findings of video games' effects on aggressive thoughts, aggressive feelings, and aggressive outcomes (Anderson, 2004; Anderson & Bushman, 2001) have found larger effects on aggressive thoughts than on aggressive feelings and arousal.

H6: Violent video games will induce higher levels of aggressive cognition than will nonviolent games.

Aggressive feelings

Although meta-analyses (Anderson, 2004; Anderson & Bushman, 2001) have found an effect of violent video games on aggressive feelings, Anderson and Dill (2000) are skeptical about a link between an enjoyed video game experience and aggressive affect: ''To be sure, playing a frustrating game is likely to increase anger. Violent content by itself, however, in the absence of another provocation, is likely to have little direct impact on affect'' (p. 774). Based on this claim that violent game content may not directly cause aggressive feelings, no specific hypotheses addressed effects of violent content on aggressive affect.

Method

All participants (N = 120) in a completely balanced, 2 (Advancement) x 2 (Violence) between-subjects factorial design were randomly assigned to one of four experimental conditions. Manipulations were accomplished using four different video games (older nonviolent game, newer nonviolent game, older violent game, and newer violent game). Data assessing presence, involvement, arousal, aggression, and other measures were collected with pre- and postexposure questionnaires and physiological measures as described below.

Participants

Initially, 125 undergraduate students were recruited to participate in the study for course credit. All participants signed an informed consent form before participation. Four participants indicated in the postexposure questionnaire that they had previously played the game to which they were assigned (or that they were unsure if they had), and a fifth participant failed to complete a page of responses on the postexposure questionnaire. These five participants were eliminated from the sample prior to analyses. Subsequent condition assignments took these removals into account to ensure equal cell sizes. The 120 final participants' mean age was 20.57 ($SD = 4.41$) and their gender makeup was 68% ($N = 82$) female. Participants were randomly assigned to conditions regardless of gender, so individual cells' gender makeup varied slightly (ranging from 60% to 80% female), but analyses did not indicate any statistically significant proportional gender disparity between conditions, $\chi^2(3, N = 120) = 2.9$, $p = .40$.[1]

Stimulus materials

Although video game technology has advanced rapidly in areas such as graphical and audio fidelity, certain game formats and genres have remained popular over time. Careful selection of stimulus materials from the universe of existing commercial video games therefore allowed the advancement factor to be manipulated effectively. From the vast array of video game genres and formats available, this study targeted personal computer versions2 of arcade style, commercially released games with linear objectives and simple computer mouse controls in order to keep the accessibility of the games' genre and format as uniform as possible. For example, a specific video game console format (e.g., Microsoft's Xbox) would have introduced discrepancies in participants' familiarity with the controller interface, and games with complicated or nonlinear strategies would have similarly introduced differences in participants' experience with specific game strategies. Arcade-style games were deemed most appropriate for the study's short exposure time, with most designed for a steep learning curve and play sessions as short as a few minutes. Computer games also represent a popular video game format: U.S. computer game sales totaled $.95 billion in 2005 (Entertainment Software Association [ESA], 2006).

This study's operationalization of video game advancement was informed by media research dealing with the effects of visual and audio fidelity (e.g., Reeves & Nass, 1996) and vividness (e.g., Coyle & Thorson, 2001; Steuer, 1992), as well as video game research suggesting potential effects of advancement as a general concept (e.g., Bensley & van Eenwyk, 2001; Gentile & Anderson, 2003; Sherry, 2001; Tamborini et al., 2004). To manipulate the advancement variable while holding others as constant as possible, we identified pairs of similar arcade-style games that were released several years apart and were perceivably different in terms of graphical and auditory quality (e.g., realism of character images and sounds). In other words, games were identified that were essentially a ''new'' and ''old'' version of one another.

Participants assigned to the two violent game conditions (newer and older) played either a PC version of *Zombie Raid*, a game released in 1995, or the 2001 PC release of *The House of the Dead 2*. In both of these ''shooter'' games, the objective is to quickly kill zombies and similar foes by guiding a targeting crosshair with the computer mouse. If the player is not quick enough, the various monsters inflict damage and eventually end the player's game. Both games feature very similar controls and content, but the newer game's presentation is notably more advanced.

To add appropriate nonviolent conditions to the study's factorial design, nonviolent games were selected with play control and pace that were as similar as possible to that of the violent games. Because most shooter games would be inappropriate for the study's nonviolent conditions, a pair of nonviolent games was selected from a different arcade-style genre that very closely matched the first-person perspective, rapid action, and targeting movements of the violent game conditions.

The two PC games selected for the study's nonviolent game conditions were *Diamonds 3D*, a game released in 1996, and *3D Arkout*, a 2003 game. In these games, the player uses the computer mouse to maneuver a paddle positioned in the screen's foreground and volley one or more balls against stylized bricks to knock down walls while collecting bonuses and avoiding detrimental game elements. When the player misses a ball with the paddle, it is lost until no more remain and the game ends. These games, like the ''shooters,'' require fast-paced and precise mouse control. As with the violent conditions, both nonviolent games feature very similar controls and content, but the newer game's presentation is notably more advanced.

Before the study, an independent pretest ($N = 48$) comparing players' perceptions of the games' advancement and violence confirmed their appropriateness for the respective conditions.

Manipulation checks

Manipulation checks used seven Likert-type items in the postexposure questionnaire (1 = ''*strongly disagree*,'' 7 = ''*strongly agree*''). To check the advancement manipulation, participants were asked to rate their agreement with each of six statements about ''The video game just played:'' that it ''had high-quality graphics,'' ''had high-quality sound,'' ''had high-quality play control,'' ''was technologically advanced,'' ''was technologically sophisticated,'' and ''was new.'' These items were combined to form a single ''perceived advancement'' index, which yielded high reliability (Cronbach's $\alpha = .91$) and unidimensionality (all six items loaded on one factor in an exploratory factor analysis and explained 68.94% of the variance). The violence manipulation was assessed by a single item asking participants to rate their agreement with the statement: ''Compared to most, the video game I just played was violent.''

Dependent variables

Presence

Perceived presence was assessed by three 7-point items from Schneider et al. (2004): ''While playing the game, how much did you feel like you were really 'there' in the game environment?'' (1 = ''*there*,'' 7 = ''*not there*''), ''While playing the game, how much did you feel like the game environment was a real place?'' (1 = ''*real*,'' 7 = ''*not real*''), and ''While playing the game, how much did you feel like other characters in the game were real?'' (1 = ''*real*,'' 7 = ''*not real*''). These items were combined to form a single ''presence'' index, which yielded acceptable reliability (Cronbach's α = .79) and unidimensionality (all items loaded on a single factor in an exploratory factor analysis and explained 71.04% of the variance).

Involvement

To measure involvement, six items adapted from Kalyanaraman and Sundar (2006) were used, with participants rating agreement (1 = ''*strongly disagree*,'' 7 = ''*strongly agree*'') with these statements: ''I paid a lot of attention to this game when I was playing,'' ''I was extremely focused on this game when I was playing,'' ''I found myself responding strongly to this game,'' ''I got involved with the goal of this game,'' ''I got emotionally involved with this game,'' and ''I experienced emotion while playing this game.'' These items were combined to form a single ''involvement'' index, which was reliable (Cronbach's α = .90) and unidimensional (all items loaded onto a single factor and explained 66.39% of the variance).

Arousal

In order to measure participants' arousal during the game play sessions, skin conductance levels (SCLs) over the duration of the video game session were measured. Data were sampled 200 times per second at a sampling rate of 66.5 Hz using a BIOPAC MP35 system (http://www.biopac.com) during two time periods. The first skin conductance measurement was a baseline measure taken for a period of 30 seconds before participants played the video game. After that, SCL was measured continuously during the 10 minutes of game play. Arousal was then calculated as the percentage change in SCL between the mean baseline level and the mean game session level. As a self-reported measure of perceived arousal, the postexposure questionnaire also included a Self-Assessment Manikin (SAM) item (e.g., Lang, Greenwald, Bradley, & Hamm, 1993) asking participants to rate the excitement felt during play using a point–point scale with graphic manikins as guides.

Aggression measures

Aggressive cognition was measured using a truncated version of Anderson, Carnagey, and Eubanks' (2003) modification of Bushman's (1996) word-association task, in which participants rate the similarity of aggressive and ambiguous word pairs. Anderson et al. (2003) state that if a violent stimulus increases participants' accessibility of aggressive thoughts, ''then ambiguous words will tend to be interpreted in a relatively more aggressive way, leading to relatively higher similarity ratings of aggressive-ambiguous pairs'' (p. 963). To reduce participant fatigue, 10 of the 20 words from the Anderson et al. version of the task were used in the present research. The aggressive words used here were ''choke,'' ''fight,'' ''hurt,'' ''kill,'' and ''wound,'' and the ambiguous words used were ''alley,'' ''animal,'' ''drugs,'' ''night,'' and ''rock.'' Using a 9-point scale (1 = ''*not at all similar, associated, or related*,'' 9 = ''*extremely similar, associated, or related*''), participants rated each of the 45 possible word pairs (20 similar, 25 dissimilar). Scores for the pairs were placed into two groups: similar word pairs (aggressive–aggressive and ambiguous–ambiguous) and dissimilar word pairs (aggressive–ambiguous). Reliability was high for both similar (Cronbach's α = .82) and dissimilar (Cronbach's α = .90) word pairs, indicating consistent responses within each type of word pair, and a paired-samples t test indicated that participants tended to assign higher similarity ratings to similar word pairs (M = 4.19, SD = 0.67) than to dissimilar word pairs (M = 3.22, SD = 0.85), $t(119) = 20.96$, $p < .001$. Each participant's mean rating for dissimilar word pairs was subtracted from the participant's mean rating for similar word pairs to produce a measure of aggressive thoughts, with smaller scores indicating greater accessibility thereof.

Aggressive affect was measured using the 35-item state hostility scale (Anderson, Deuser, & DeNeve, 1995), with 7-point Likert-type items assessing participants' agreement with various statements about their emotional state (e.g., ''I feel furious, I feel sympathetic''). These items displayed high reliability (Cronbach's α = .95). Presentation order of the word-association task and state hostility scale was counter-balanced to account for potential influence of one aggression measure on the other (see Anderson et al., 2003; Lindsay & Anderson, 2000); In each experimental condition, half of the participants received the word-pair task first in the questionnaire and half received the state hostility items first.

Other measures

For use in compiling descriptive statistics and for creating control measures, a preexposure questionnaire also included items assessing participants' age, gender, hours spent playing video games per week, familiarity with video games (1 = ''*not at all familiar*,'' 7 = ''*very familiar*''), and general experience playing video games (1 = ''*much less than most people*,'' 7 = ''*much more than most people*''). A 14-item semantic differential scale adapted from measures used by Kalyanaraman and colleagues (e.g., Crystal & Kalyanaraman, 2004; Kalyanaraman & Oliver, 2001; Sundar & Kalyanaraman, 2004) was also used in the preexposure questionnaire to assess general attitudes toward video games (e.g., ''*good/bad*,'' ''*appealing/unappealing*''). Responses to these items were combined into a single index, which was reliable (Cronbach's α = .91). A pair of preexposure questions measured relative game type preference by asking participants to rate agreement (1 = ''*strongly disagree*,'' 7 = ''*strongly agree*'') with the statements ''I enjoy violent video games'' and ''I enjoy nonviolent video games.'' Postexposure questionnaire items assessed agreement with the statement ''I was frustrated by this game'' (1 =''*strongly disagree*,'' 7 = ''*strongly agree*''), measured how often participants had played games similar to the one they played in the session (1 = ''*not often at all*,'' 7 = ''*very often*''), and asked whether participants had ever previously played the game to which they were assigned (''yes,'' ''no,'' or ''unsure''). All participants included in the study answered no in response to this item (see Participants section).

Procedure

All participants took part in the experiment in individual sessions. After participants completed the preexposure questionnaire, they were seated at a desktop PC computer equipped with a 17-inch LCD monitor, speaker, keyboard, and mouse. The experimenter then cleaned participants' hands with distilled water and a paper towel, applied electrode jelly to the contact areas of two reusable Ag–AgCl electrodes with 6-mm contact areas (mounted in molded polyurethane housings fitted with a Velcro strap), and attached them to the index and middle fingers of their nondominant hand for measurement on the palmar surface of the distal phalanx (see Scerbo, Freedman, Raine, Dawson, & Venables, 1992). After obtaining the 30-second baseline skin conductance measure, the experimenter gave participants a one-page sheet containing instructions for the video game. When the participants indicated that they were ready to play, the experimenter started the game and obtained the second skin conductance measurement throughout the 10-minute game-play session. When a game ended during a session (i.e., when a participant ran out of turns), it restarted from the beginning. Although the frequency of these restarts during a session varied slightly depending on participants' skill, most participants went through at least one restart during their session. After 10 minutes of game play, participants completed the postexposure questionnaire and were debriefed, thanked for their participation, and dismissed.

Results

Descriptive statistics

Participants' mean reported time spent playing video games per week was .29 hours (*SD* = 0.57). Their mean reported familiarity with video games was 3.27 (*SD* = 1.74) on the 7-point scale, and the mean for participants' reported experience playing video games throughout their lives ''compared to most people'' was 3.12 (*SD* = 1.60) on the 7-point scale.

Manipulation checks

Advancement

To test the efficacy of the advancement manipulation, a two-way analysis of variance (ANOVA) was run with advancement and violence as independent factors and the perceived advancement index as the dependent variable. The effect of advancement was significant, $F(1, 116) = 30.60$, $p < .001$, $\eta_p^2 = .21$, with perceived advancement scores higher for the newer game condition (M=3.63, SD = 1.29) than for the older game condition ($M = 2.57$, $SD = 0.82$). The main effect of violence, $F(1, 116) = 2.06$, $p = .15$, $\eta_p^2 = .02$, and interaction effect between advancement and violence, $F(1, 116) = .68$, $p = .41$, $\eta_p^2 = .006$, were not statistically significant.

Violence

To test manipulation of the violence condition, a two-way ANOVA was run with violence and advancement as the independent factors and perceived violence as the dependent variable. The ANOVA revealed a statistically significant main effect for violence $F(1, 116) = 798.61$, $p < .001$, $\eta_p^2 = .87$, with perceived violence higher for the violent game condition ($M = 6.05$, $SD = 0.96$) than for the nonviolent game condition ($M = 1.27$, $SD = 0.88$). The effect of advancement on the perceived violence item was not statistically significant, $F(1, 116) = 1.41$, $p = .24$, $\eta_p^2 = .01$, nor was the interaction effect between advancement and violence, $F(1, 116) = .98$, $p = .33$, $\eta_p^2 = .008$. In summary, both manipulations were successful.

Analysis of potential control variables

The index assessing participants' attitudes toward video games in general (e.g., Crystal & Kalyanaraman, 2004; Kalyanaraman & Oliver, 2001; Sundar & Kalyanaraman, 2004) was correlated with the other control measures assessing familiarity with games (Pearson's $r = .63$, $p < .001$), experience with games in general (Pearson's $r = .58$, $p < .001$), and experience with similar games to the one played during the session (Pearson's $r = .41$, $p < .001$). To avoid problems related to multicollinearity, these four measures were combined to form a single ''prior experience'' index for use as a control variable. This index was reliable (Cronbach's $\alpha = .84$) and unidimensional (all items loaded on a single factor and explained 69.74% of the variance).[3] Participants' scores on the preexposure questionnaire item assessing enjoyment of nonviolent video games were subtracted from their scores for enjoyment of violent video games to create a measure of relative preference for video game type. The mean score for this measure was 21.22 (SD = 1.80), meaning that participants tended to slightly prefer nonviolent games. This relative preference measure was also used as a control variable, as was the postquestionnaire item assessing frustration experienced during the game play session.

Preparation of physiological data

Examination of SCL waveforms indicated two clear instances where measurement was flawed because of inconsistent measurement by the electrode (i.e., the results indicated no measurement SCL for part of the session or an extremely dramatic change during the session). Because these participants completed the experimental procedure and all questionnaire measures without problems, the sample's mean SCL change was imputed to these cases to preserve their inclusion in the data set. The distribution of the SCL percentage change measure was also susceptible to positive skewing because SCL can increase up to and greatly exceeding 100% but cannot decrease by more than 100% from the baseline (lower than zero). To reduce this positive skew while preserving cases' inclusion in the data set, outliers were also identified and replaced with the sample mean to obtain a sufficiently normal distribution. To minimize the number of cases selected for mean imputation, only scores of at least two standard deviations ($SD = 0.63$) above or below the mean SCL change ($M = .46$) were replaced. The SCL scores of four cases fell outside of this range (-0.80 to 1.72 or -80% to 172%) and were thusly replaced. After this procedure, the distribution of the SCL data did not depart significantly from normality according to Hutcheson and Sofroniou's (1999) guidelines.

Multivariate results

To test for omnibus effects of advancement and violence on the experience variables as a check against alpha inflation from multiple univariate tests (see Leary & Altmaier, 1980), a 2 x 2 multivariate analysis of covariance (MANCOVA) was run with advancement and violence as independent factors and the prior experience index, preference for video game type, and frustration experienced during play as covariates. Dependent variables were the presence and involvement indexes, SCL change, self-reported excitement, aggressive cognition, and aggressive affect.

The omnibus MANCOVA results indicated significant effects of advancement, $F(6, 108) = 3.00$, $p < .01$, $\eta_p^2 = .14$, but no significance was found for the effects of violence, $F(6, 108) = 1.62$, $p = .15$, $\eta_p^2 = .08$, or the interaction effect between advancement and violence, $F(6, 108) = .49$, $p = .81$, $\eta_p^2 = .03$. Among covariates, the effect of frustration was significant, $F(6, 108) = 5.30$, $p < .001$, $\eta_p^2 = .23$, but no significance was found for the effects of the prior experience index, $F(6, 108) = .64$, $p = .70$, $\eta_p^2 = .03$, or preference for game type, $F(6, 108) = 1.64$, $p = .14$, $\eta_p^2 = .08$. These MANCOVA results informed subsequent univariate analyses by suggesting that significant univariate effects of the advancement factor were not likely artifacts of alpha inflation, but that any significant univariate effects of the violence factor or significant interaction effects could be due to alpha inflation and should thus be regarded cautiously.

Univariate analysis of covariance (ANCOVA) tests on each dependent variable followed, with all three covariates included. Additionally, corresponding ANOVA tests were run on each dependent variable without the covariates to check whether significance of test results was consistent without covariates. Where these supplemental ANOVA tests produced identical results regarding statistical significance, only the ANCOVA tests are reported here to avoid redundancy.

Presence

H1 predicted that the newer video games would induce higher levels of presence in game players. A two-way ANCOVA with advancement and violence as the independent variables and the presence index (Schneider et al., 2004) as the dependent variable revealed a main effect of advancement, $F(1, 113) = 7.68$, $p =$, .01, $\eta_p^2 = .06$, with players of the newer games (adjusted $M = 2.47$) reporting higher presence scores than players of the older games (adjusted $M = 1.90$). Significance was not found for the main effect of violence, $F(1, 113) = .435$, $p = .51$, $\eta_p^2 = .004$, or the interaction effect between advancement and violence, $F(1, 113) = 2.30$, $p = .13$, $\eta_p^2 = .02$. (See Table 1 for a summary of univariate ANCOVA results.) No covariates were significant in the model, and an ANOVA test without the covariates produced no differences in significance for main or interaction effects. These results support H1.

Involvement

H2 predicted that the newer video games would make players feel more involved. A two-way ANCOVA with advancement and violence as the independent variables and

Table 1 Summary of Adjusted Means for Dependent Variables and Analysis of Covariance *F* Values

	Advancement				Violence			
Measure	Newer	Older	*SE*	*F*	Violent	Non	*SE*	*F*
Presence	2.47	1.89	0.15	7.68**	2.11	2.25	0.15	0.44
Involvement	4.71	4.20	0.17	4.50*	4.36	4.55	0.17	0.59
Skin conductance level arousal change	0.47	0.32	0.04	5.67*	0.40	0.39	0.05	0.05
Self-assessment manikin excitement	5.67	4.80	0.20	9.40**	5.38	5.08	0.20	2.11
Aggressive cognition	0.94	1.00	0.07	0.43	1.01	0.93	0.07	0.17
Aggressive affect	2.61	2.55	0.11	0.13	2.73	2.43	0.11	3.83

**p* < .05. ***p* < .01.

the involvement index (Kalyanaraman & Sundar, 2006) as the dependent variable found similar effects to those observed with the presence index. There was a main effect of advancement, $F(1, 113) = 4.50$, $p < .05$, $\eta_p^2 = .04$, with the newer games (adjusted $M = 4.71$) receiving higher involvement scores than the older games (adjusted $M = 4.20$). However, significance was not found for the main effect of violence, $F(1, 113) = .59$, $p = .45$, $\eta_p^2 = .005$, or the interaction effect between advancement and violence, $F(1, 113) = 1.14$, $p = .29$, $\eta_p^2 = .01$. Only frustration was significant as a covariate, $F(1, 113) = 11.42$, $p = .001$, $\eta_p^2 = .09$ (positive beta). Conducting the analysis as an ANOVA test without the covariates produced no differences in significance. These results support H2.

Arousal

H3 predicted that the newer video games would induce higher levels of arousal in their players. H4 predicted that the violent games would induce higher levels of arousal compared to the nonviolent games, and H5 predicted an interaction effect with advancement causing a greater increase in arousal for the violent game than for the nonviolent game. All of these hypotheses were tested for both the skin conductance and self-reported excitement measures.

Skin conductance

A two-way ANCOVA with advancement and violence as the independent variables and percentage change in SCL as the dependent variable revealed a main effect of advancement, with a greater increase in arousal induced by the newer games (adjusted M = .47) than by the older games (adjusted $M = .32$), $F(1, 113) = 5.67$, $p > .05$, $\eta_p^2 = .05$. The main effect of violence on arousal change was not significant, $F(1, 113) = .05$, $p = .83$, η_p^2, .001, nor was the interaction effect between advancement and violence, $F(1, 113) = .001$, $p = .97$, $\eta_p^2 < .001$. Only frustration was significant as a covariate, $F(1, 113) = 4.87$, $p < .05$, $\eta_p^2 = .05$ (positive beta). Conducting the analysis as an ANOVA test without covariates did not affect significance.

Self-reported excitement

A two-way ANCOVA using the SAM excitement measure (Lang et al., 1993) revealed the same pattern of effects found with the SCL measure: A main effect of advancement was observed, $F(1, 113) = 9.40$, $p < .01$, $\eta_p^2 = .08$, with newer games (adjusted $M = 5.67$) eliciting higher excitement scores than older games (adjusted $M = 4.80$). The main effect of violence was not significant, $F(1, 113) = 2.11$, $p = .15$, $\eta_p^2 = .02$, nor was the interaction effect between advancement and violence, $F(1, 113) = .73$, $p = .39$, $\eta_p^2 = .006$. Only frustration was significant as a covariate, $F(1, 113) = 4.90$, $p < .05$, $\eta_p^2 = .04$ (positive beta). Conducting the analysis as an ANOVA test without the covariates produced no differences in significance.

These results for both skin conductance and self-reported excitement therefore support H3 but fail to support H4 or H5.

Aggression

Aggressive cognition

H6 predicted that violent video games would induce more aggressive thoughts. In a two-way ANCOVA with advancement and violence as the independent variables and the aggressive cognition measure (Anderson et al., 2003) as the dependent variable, significance was not found for the main effects of violence, $F(1, 113) = .66$, $p = .42$, $\eta_p^2 = .006$, or advancement, $F(1, 113) = .43$, $p = .51$, $\eta_p^2 = .004$. In fact, higher accessibility of aggressive thoughts was induced by the nonviolent game (adjusted $M = .93$) than by the violent game (adjusted $M = 1.00$), though the effect was not significant. The interaction effect between advancement and violence was not significant, $F(1, 116) = .03$, $p = .86$, $\eta_p^2 < .001$. No covariates were significant in the model, and conducting the analysis as an ANOVA test without the covariates produced no differences in significance. H6 is therefore disconfirmed.

Aggressive affect

Analyses also investigated unpredicted effects of advancement and violence on aggressive affect. In a two-way ANCOVA with advancement and violence as the independent variables and the state hostility scale (Anderson et al., 1995) as the dependent variable, the main effect of violence was marginally significant, $F(1, 113) = 3.83$, $p = .053$, $\eta_p^2 = .03$, with players of violent games (adjusted $M = 2.73$) reporting higher levels of state hostility than players of nonviolent games (adjusted $M = 2.43$). No significance was found for the effect of advancement, $F(1, 113) = .13$, $p = .72$, $\eta_p^2 = .001$, or the interaction effect, $F(1, 113) = .15$, $p = .70$, $\eta_p^2 = .001$. Among the controls, only frustration was a significant predictor, $F(1, 113) = 19.69$, $p < .001$, $\eta_p^2 = .15$. The veracity of the marginally significant effect, however, is called into question by the aforementioned multivariate analysis of variance (MANOVA) results showing no significant effect of violence, which suggest that this effect on aggressive feelings may be result from alpha inflation. It should also be noted that when an ANOVA test was conducted excluding the covariates, the main effect of violence was no longer significant, $F(1, 116) = 1.96$, $p = .15$, $\eta_p^2 = .02$.

Summary of results

In brief, then, the upshot of these results is that technological advancement in video games increased players' sense of presence, feelings of involvement, and arousal but did not significantly affect aggressive thoughts or feelings. Violence had no significant effect on presence, involvement, arousal, or aggressive thoughts but may have increased participants' hostility. This last finding, though, should be interpreted cautiously in light of the nonsignificant multivariate effect of violence, as well as the observed effect's sensitivity to controls.

Discussion

Some researchers tout video games as a powerful educational tool that is tailor-made to assist learning and the development of cognitive and motor skills (e.g., Gee, 2003; Green & Bavelier, 2003; Miskry, Magos, & Magos, 2002). Others warn that the same features may encourage players of violent video games to commit imitative real-life violence after the game is turned off (e.g., Gentile & Anderson, 2003). In any case, continuous and rapid technological advancement in video games (Carnagey & Anderson, 2004; Gentile & Anderson, 2003) is worthy of attention. Even so, research has too often left the effects of advancement on players' experiences with video games largely unaddressed. The present investigation attempted to make a contribution by investigating the effects of advancement and violence on several game-experience dimensions.

Theoretical implications

Advancement

As predicted by H1, H2, and H3, technological advancement was found to increase video game players' presence, involvement, and physiological arousal. These findings fill a gap in the literature on video game effects by indicating that technological advancement in video games impacts the user experience along important dimensions. Much scrutiny has been applied to the effects of video games' content, but this experiment indicates that games' technological form dimensions also have important effects, and that they are similar to those observed with other media (e.g., Bracken, 2005; Detenber et al., 1998; Lombard et al., 2000; Reeves et al., 1999). The theoretical link between technological advancement and presence, involvement, and arousal appears to be robust across a variety of media including video games.

The effects of advancement observed here also suggest that careful, isolated manipulation of form variables is necessary to identify their effects. Tamborini et al. (2004) found no significant difference between feelings of presence elicited by an advanced virtual reality game and those elicited by a computer-based video game, but the present study found an effect of advancement on feelings of presence without varying the interface system at all. Tamborini et al. provide a possible explanation why our technological advancement manipulation had an effect on presence that was not elicited by their ostensibly stronger manipulation: They speculate that their use of different game control systems may have introduced any of a number of confounds affecting perception and experience dimensions in unexpected ways. By isolating advancement while holding control dimensions constant, our study may have eliminated such confounds. When compared to the null results of the Tamborini et al. advancement manipulation, the present study's results suggest that manipulating a single-form dimension (here, advancement in presentation) while making efforts to hold all others relatively constant (e.g., game controls) is an ideal strategy for identifying effects of form variables with clarity.

Violent content

As for violent content, significant effects on many dimensions of the video game experience were lacking. Although H4 predicted that violent content would increase players' arousal, no such effect was observed. Other violent media have been found to be particularly conducive to arousal (Sparks & Sparks, 2002), so one interpretation of this null finding is that with video games, content may not be as meaningful as other game dimensions (such as technological variables) as a predictor of arousal. More studies examining effects of content dimensions in concert with other game features, however, are needed to further an understanding of these factors' relative influence on the game experience.

H6 predicted that violent content would increase accessibility of aggressive thoughts in players because aggressive cognition has been viewed as a key route by which violent video games might influence player aggression (e.g., Anderson & Bushman, 2001; Anderson & Dill, 2000), but this hypothesis was disconfirmed. There are many studies indicating a link between violent video game play and aggressive thoughts (see Anderson, 2004; Anderson & Bushman, 2001), but this research does not add support for the existence of this link.

Although no hypothesized effects of violence on arousal or violent thoughts were observed, the GAM may be informed by this study's very tentative finding that violent content increased aggressive affect after controlling for frustration and factors pertaining to experience and preferred game type. Given that numerous studies have found a relationship between violent game play and aggressive feelings (see Anderson & Bushman, 2001), perhaps it is too soon to downplay the role of aggressive affect in the possible effects of violent video game play on player aggression. The significance of frustration as a control measure in the present study suggests that it may be important to ensure that frustration is accounted for in research on video games and aggressive affect. In other studies testing for effects of violent video game play on aggressive affect (e.g., Scott, 1995), failing to account for measures such as frustration may have obscured effects of violent content on aggressive affect. Although the present study's finding regarding violent content and aggressive affect was unpredicted and may have been a product of alpha inflation, it points to some support for a link between violent games and aggressive affect as well as to the importance of frustration as a control measure.

In response to concern that newer video games might bring about stronger and more troubling negative effects (e.g., Bensley & van Eenwyk, 2001), however, the present study found no unique effects of advancement on aggressive thoughts or feelings induced by violent games. Although H5 predicted an interaction between the effects of advancement and violence on physiological arousal, this effect was not observed. In fact, this research did not find that advancement uniquely impacted any effects of violent content, as no significant interaction effects were observed between the two factors. These findings therefore show little support for speculation and consternation that advancement exacerbates the possible negative effects of violent games in particular. The argument over whether violent video game content encourages aggression will no doubt continue, but the findings reported here are consistent with other research (e.g., Tamborini et al., 2004) in failing to implicate technological advancement as an intensifier of violent games' possible negative effects. This research suggests that effects of advancement are not especially different for violent games than for nonviolent games.

Practical implications

The present study also provides useful insights for those aiming to produce popular video games or maximize their positive potential. Efforts to develop more realistic, sophisticated games seem to be justified by our findings that advancement in games increases feelings of ''being there'' experienced by players, as well as involvement and excitement. This evidence has commercial implications, but also suggests that more advanced games will be more captivating in an educational or otherwise instructive setting. These positive effects of advancement can also be realized without extravagant game interfaces and features that might elude educational efforts. After all, the games used here were released less than a decade apart and required only a PC andmouse, but effects of this modest variation in advancement were observed nonetheless.

This study's failure to observe significant effects of violent content on most game-experience dimensions is also instructive for game development and application. One might assume that the many violent video games are more thrilling and action packed than their nonviolent counterparts, but the results of this research do not indicate that violent video game content is by itself more immersive, involving, or exciting than nonviolent content. Emphasis on developing advanced and engaging noncontent features may instead be the key to appeal.

Limitations

Commercially available video games were used in this research, which provided realistic and natural stimulus materials and enhanced external validity. Unfortunately, selection of these games also prevented strict control over all stimulus dimensions. Despite the vast number of commercial video games on the market, four different games that manipulate advancement and violence while holding all other dimensions of game play precisely constant are simply unobtainable. The games used, however, were carefully selected to manipulate the advancement and violence factors while holding other game dimensions as constant as possible. In addition, the manipulations used here do not represent all dimensions of advancement and violence in the diverse universe of video games. This study's manipulation checks, internal reliability of responses to the perceived advancement index, and observed effects on dependent variables indicate that participants' perceptions of game advancement support the validity of our operationalizations, but these findings cannot speak for the effects of all possible advancement and violence dimensions in video games.

Similarly, the arcade-style PC games used here are not generalizable to all video game genres and formats. Given the vast number of video games and machines on which they can be played—over 35,000 games and 93 machines plus computers, according to Williams (2006)—no set of video game stimulus materials has unlimited generalizability. Video game research must acknowledge that studies using any given video game type are no more broadly generalizable than are studies employing specific movie genres (Dill & Dill, 1998). No controlled experiment has unlimited generalizability, of course. The present study, whose stimulus materials were carefully selected to maximize design controls while representing commercial games from a popular game format and style, nonetheless serves as an effective starting point for future research on the effects of technological dimensions using other contexts and operationalizations.

Another limitation of the study involves the demographic makeup of its participants. While these participants were college aged, the effects of video games on a younger audience might be different—and may also be of more interest to those concerned about video games' negative effects. This study's participants do, however, represent a large adult population of video game users. Adult video game players now represent a sizable portion of the video game audience: The average player is 33 years old, and only 31% of players are under 18 (ESA, 2006). Considering such figures, this sample of young adults seems an adequate participant base for this novel study. This study's gender makeup is ostensibly problematic, as it included a female majority even though 62% of video game players are male (ESA, 2006). Gender, however, was not found to affect the dependent variables of interest, and the robustness of findings to various other controls serve as a testament to the uniformity of the effects of advancement observed here. That said, additional studies of advancement's effects with participants of different demographic makeup and gaming experience (e.g., varied age groups, hardcore enthusiasts), would add to the understanding provided by this study.

Future research

The insights gained here, as well as consideration of this study's limitations, present many opportunities for future research. Based on this evidence that game advancement impacts players' experiences, further research can pursue a more detailed understanding of specific technological form dimensions' effects. Such precise investigation of the effects of advancement dimensions could be accomplished using the variable-centered approach (Nass & Mason, 1990) to isolate specific features and assess their unique effects. By using this perspective with video games, research can continue to investigate specific effects of certain technological form variables individually (e.g., graphic resolution, sound quality, responsiveness of play control).

To effectively manipulate technological dimensions with such precision, however, more control over stimulus materials is necessary. To complement the present study's findings, which were obtained using commercially available games, research investigating the unique effects of specific technological dimensions would benefit from access to commercial-quality games that can be altered specifically for research to create precisely controlled experimental conditions. This goal can be achieved through increased cooperation between effects researchers and game programmers and designers. Until such studies are conducted with regularity, however, wide variety in commercial games allows manipulations such as those used here.

This study's findings, showing no main effects of violence on arousal or aggressive thoughts but very tentatively indicating a possible increase in aggressive affect due to violent content, add to an already conflicting milieu of literature describing the possible effects of violent game content on aggression. Perhaps is it time to look at violent content in video games less broadly. Most studies, including this one, use only one operationalization for violent and nonviolent conditions, but there are many different types of violent games that may have differential effects on players (see Sherry, 2001). More exploration of different types of game violence, such as justified versus unjustified violence or nonlethal violence versus lethal violence, might further draw out the elusive effects of violence on aggression. The present findings also emphasize the importance of control measures, such as frustration, in measurement of game contents' effects on aggressive affect. In addition to continued use of frustration as a control measure, research that intentionally manipulates frustration as an independent variable might prove insightful in exploring the effects of this important gameexperience dimension. By taking such factors into careful consideration, further research may more clearly elucidate the link between video game violence and aggression.

Coda

The results of this investigation suggest that advancement in video games facilitates a more immersive, involving, exciting player experience. For those interested in the potential of video games as a medium rich with entertainment and educational potential, these findings are promising. For those concerned about whether more thrilling and involving games will lead to addiction and imitation, they may be somewhat troublesome. When it comes to video games, is newer better? The answer may depend on just what is meant by ''better.''

Notes

1 Preliminary MANCOVA and ANCOVA analyses of relationships between gender and dependent variables found that gender had neither a significant multivariate effect nor

significant univariate main effects on any of the dependent variables, so analyses were collapsed across gender in this study.

2 Although a strict distinction in nomenclature might be made between ‘‘video games’’ played on an arcade or console unit and ‘‘computer games’’ played on a personal computer, we here use the general term video games to describe popular games played on arcade systems, consoles, and computers (including those used in this study). This general use of the term video games to apply to a number of formats is common in popular parlance as well as recent research on the effects of video games (e.g., Schneider et al., 2004; Tamborini et al., 2004; Williams, 2006; Williams & Skoric, 2005).

3 Ostensibly, the ‘‘attitude toward video games in general’’ measure taps a conceptually different dimension than the measures assessing experience and familiarity with video games, calling into question its inclusion in the index. The correlation of the attitude measure with the other three assessing familiarity and experience, however, suggests that experience and familiarity with video games are related closely enough to attitudes toward video games that the measures all tap a general dimension of participants’ level of acquaintance and comfort with the medium.

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