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A Longitudinal Study of the Association Between Violent Video Game Play and Aggression Among Adolescents

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In the past 2 decades, correlational and experimental studies have found a positive association between violent video game play and aggression. There is less evidence, however, to support a long-term relation between these behaviors. This study examined sustained violent video game play and adolescent aggressive behavior across the high school years and directly assessed the socialization (violent video game play predicts aggression over time) versus selection hypotheses (aggression predicts violent video game play over time). Adolescents (N = 1,492, 50.8% female) were surveyed annually from Grade 9 to Grade 12 about their video game play and aggressive behaviors. Nonviolent video game play, frequency of overall video game play, and a comprehensive set of potential 3rd variables were included as covariates in each analysis. Sustained violent video game play was significantly related to steeper increases in adolescents' trajectory of aggressive behavior over time. Moreover, greater violent video game play predicted higher levels of aggression over time, after controlling for previous levels of aggression, supporting the socialization hypothesis. In contrast, no support was found for the selection hypothesis. Nonviolent video game play also did not predict higher levels of aggressive behavior over time. Our findings, and the fact that many adolescents play video games for several hours every day, underscore the need for a greater understanding of the long-term relation between violent video games and aggression, as well as the specific game characteristics (e.g., violent content, competition, pace of action) that may be responsible for this association.

Keywords: violent video game play, aggression, adolescence, socialization versus selection hypothesis, longitudinal

Video game play is ubiquitous among adolescents. Data from the first nationally representative study of video game play in the United States indicate that 97% of adolescents age 12 to 17 years play computer, Web, portable, or console video games, with 31% of the sample playing on a daily basis and another 21% playing 3 to 5 days a week (Lenhart et al., 2008). What is concerning, however, is that over half of the adolescents surveyed reported playing violent video games, and five of the 10 most frequently played games were assessed as violent. The high prevalence of violent video game play among youth has led researchers to consider whether playing these types of games may be associated with aggressive/violent behavior and has led to intense debate about their potential harm to children—for example, a case involving the sale and rental of violent video games to children recently was considered by the U.S. Supreme Court (Lang, 2010).

In the past two decades, several studies have found a positive correlation between violent video game play and aggression among adolescents and young adults. Similarly, it has been demonstrated in experimental research that playing violent video games temporarily increases aggressive behavior, aggressive cognition, aggressive affect, and physiological arousal (see Anderson, 2004; Anderson, Gentile, & Buckley, 2007). There is less evidence, however, to support a long-term relation between violent video games and aggression, as very few longitudinal studies have been conducted (e.g., Anderson et al., 2007, 2010; Möller & Krahé, 2009; Wallenius & Punamäki, 2008). The goal of the current study, therefore, is to extend the body of literature on the relation between violent video game play and aggression by presenting a comprehensive analysis of the long-term association between violent video games and adolescent aggressive behavior.

Theories of Violent Video Game Play and Aggression

Several theoretical perspectives offer explanations for why violent video game play may be associated with increased aggressive behavior. From a social learning perspective, adolescents who play violent video games may imitate the aggression that they observe in the games (Bandura, 1977). In the excitation transfer theory, Zillmann (1983) posited that the transfer of physiological arousal may be a mechanism through which observing violence may lead to aggressive behavior. Specifically, physiological arousal from a stimulus (e.g., violent video games) can linger after that stimulus is gone and can transfer to a future encounter (even without awareness), increasing the chance of aggressive behavior. In Berkowitz's (1990) cognitive neoassocation model, playing violent video games can create or activate networks of aggressive thoughts, emotions, and memories through aggressive cues, such as feelings of frustration or violent imagery. Thus, violent video game play may influence aggressive behavior through spreading activation of aggressive networks.

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The most comprehensive theory of the association between violent video games and aggression is Anderson and Bushman's (2002) general aggression model, which was adapted from past theories of aggression (see also Anderson & Carnagey, 2004, for a detailed description of the model). According to Anderson and Carnagey (2004), in the long term, repeated exposure to violent video games may influence aggressive behavior by promoting aggressive beliefs/attitudes, such as creating normative beliefs about aggression. In addition, long-term violent video game play may create aggressive behavioral scripts and expectations. For example, violent video game play may encourage a hostile attributional bias, such as when a person consistently interprets ambiguous situations as hostile (Nasby, Hayden, & DePaulo, 1980). Thus, long-term violent video game players may become more likely to react aggressively to unintentional provocations, such as when someone accidentally bumps into them. Furthermore, the result of promoting aggressive beliefs, attitudes, behavioral scripts, and expectations is that an individual's personality can become biased toward aggression. In other words, according to Anderson and Bushman, each violent video game episode may reinforce the notion that aggression is an effective and appropriate way to deal with conflict and anger.

The theoretical focus on the link between violent video game use and aggression has been primarily on the violent content of the games, but other game characteristics, such as competition and pace of action, also may be important. In fact, all of these game characteristics could interact to influence aggression. For example, the high level of competition and the fast pace of action often found in violent video games may increase physiological arousal, and this arousal might result in aggressive behavior (Anderson & Morrow, 1995; see Deutsch, 1949; Rocha & Rogers, 1976; and Sherif & Sherif, 1956, for a discussion of the link between competition and aggression). Consistent with Berkowitz's (1989) frustration–aggression hypothesis, competition in video games also may influence frustration if the player is losing in a competitive game, which in turn may elevate aggressive behavior. In addition, competitiveness may influence aggressive cognitions by activating associative links between aggression and competition developed through a variety of past experiences with competitive situations that have resulted in aggressive outcomes (Anderson & Carnagey, 2009; Anderson & Morrow, 1995). Thus, in the long term, competitive and fast-paced video game play may teach people that aggression is an appropriate way of dealing with related increases in frustration and arousal. Prior to turning to the empirical research in this area, however, it is important to note that most video game studies, including the present study, have not isolated the impact of these different game characteristics (i.e., violent content, competition, pace of action) when examining the association between violent video games and aggression (but see Adachi & Willoughby, 2011a, and Anderson & Carnagey, 2009, for short-term experimental studies examining the differential impact of competition vs. violent content on aggression).

Empirical Background

Researchers have made numerous attempts to empirically validate the hypothesis that violent video game play is linked to increased aggressive behavior in both correlational (e.g., Gentile, Lynch, Linder, & Walsh, 2004) and experimental (e.g., Anderson & Dill, 2000) research (see Anderson et al., 2010, for a review). Neither correlational nor experimental studies, however, provide any information on the potential long-term effects of violent video game play on aggression. To date, only a few longitudinal studies have examined the relation between violent video games and aggression. The majority of these studies have found that violent video game play at one point in time predicts higher levels of subsequent aggressive behavior. For instance, in a 6-month study investigating the effects of violent video games on the aggression of fourth and fifth grade students, Anderson et al. (2007) found that violent video game use at the first wave of assessment predicted higher levels of physical and verbal aggression, as well as lower levels of prosocial behavior, at the second wave, after controlling for initial scores. In another study, Möller and Krahé (2009) assessed the link between violent video game play and both direct and indirect aggressive behaviors in a 30-month longitudinal study of German adolescents (M age = 13.34 years at Time 1). Results indicated that exposure to violent video games at Time 1 predicted direct (but not indirect) aggression at Time 2, after controlling for direct aggression at Time 1 (see also Hopf, Huber, & Weiβ, 2008). There has also been some longitudinal research regarding violent video games and aggression conducted in Japan. For instance, Anderson et al. (2008) found that after controlling for gender and past aggression, violent video game play predicted higher levels of aggression among adolescents 3 to 6 months later, in comparison to participants who played less violent video games. In contrast, in a 2-year longitudinal study with adolescents age 12 and 15 years, Wallenius and Punämaki (2008) found that frequency of violent video game play at Time 1 did not predict direct aggression scores at Time 2 when controlling for direct aggression scores at Time 1.

A major limitation of the body of literature examining the longitudinal association between violent video game play and aggression, however, is that it is composed almost entirely of short-term studies, where participants are assessed at only two time points across a time span of 2 years or less. In a recent meta-analysis of the research examining the link between violent video game play and aggression, Anderson et al. (2010) argued that longitudinal studies with longer intervals between the first and last time periods need to be conducted. Furthermore, the focus of past longitudinal studies has been on the prediction of aggressive behavior at one point in time from the frequency of violent video game play at an earlier point in time. While the findings from these studies have been valuable, they have not provided any information on the association between sustained violent video game play over many years and aggressive behavior. For example, although Möller and Krahé (2009) found that adolescents who played violent video games at Wave 1 were more aggressive at Wave 2 after controlling for aggression at Time 1, it is not known if adolescents who played violent video games at both time points (i.e., sustained players) were more aggressive than adolescents who played only at one time point. It may be that the sustained playing of violent video games over many years has a cumulative effect on individuals' aggressive behavior over the same period of time. No studies of which we are aware have assessed the association of sustained play and aggression, and this omission represents a significant gap in the literature.

Another notable limitation of the longitudinal studies on the relation between violent video game play and aggression is that the majority have considered only the unidirectional effect of violent video games on aggression (i.e., the socialization hypothesis, which represents the theory that violent media causes viewers to be more aggressive). It is equally possible, however, that individuals who are more aggressive are more likely to be attracted to violent media such as violent video games (i.e., the selection hypothesis). The few studies that have considered the socialization and selection hypotheses simultaneously have found mixed results. Anderson et al. (2007), for instance, found support for both the socialization and selection hypotheses; not only were higher violent video game scores at Time 1 related to higher levels of aggression at Time 2, but higher physical and verbal aggression scores at Time 1 were related to higher levels of violent video game play at Time 2 (although these lagged correlations only controlled for initial aggression, not violent video game play). In contrast, Möller and Krahé (2009) found support only for the socialization hypothesis, as violent video game play predicted higher levels of aggression 30 months later (after controlling for initial aggression), but aggression did not predict more violent video game play 30 months later (after controlling for initial video game play). Support for the socialization hypothesis also is consistent with findings from long-term studies of the association between viewing television violence and aggression; that is, preference for television violence viewing was related to higher levels of aggressive behavior over time, but not vice versa (see Eron, Huesmann, Lefkowitz, & Walder, 1972; Huesmann, Moise-Titus, Podolski, & Eron, 2003). To determine more conclusively whether the socialization hypothesis also most accurately reflects the nature of the relation between violent video game play and aggression, more research examining bidirectional effects is needed.

There also have been limitations in this body of literature with regard to the operationalization and measurement of violent video game play. For example, although Möller and Krahé's (2009) study is perhaps the most comprehensive longitudinal study to date of the association between violent video games and aggression over time, there were limitations with the way in which violent video game play was measured in the study. Specifically, participants rated how frequently they played a list of 40 video games. Experts then rated each of the games for level of violence. A violence frequency index was computed by multiplying the frequency rating for each game (0 = *never* to 4 = *very often*) by the violence rating for that game (1 = *free of violent content* to 5 = *high violent content*), and then averaging across the 40 games. Of the 40 games, however, 17 (43%) had violence ratings under 2.5 (the scale midpoint), and thus were relatively nonviolent. Furthermore, since several of the nonviolent games (i.e., low violence ratings) had high frequency ratings (e.g., the most frequently played game was *FIFA Football,* which had a violence rating of 1), these nonviolent games were strong contributors to the violence frequency index score. An individual who reported playing several nonviolent games very frequently, for instance, could receive a higher score on the violence frequency index than an individual who played one violent video game infrequently. Therefore, Möller and Krahé did not isolate violent video game play from frequency of play; it is possible that the results might have differed if they had used a scale that reflected the frequency with which individuals played violent video games.

Similarly, the majority of longitudinal studies assessing the relation between violent video game play and aggression have failed to directly test the effects of both violent video game play as well as nonviolent video game play. Although Anderson et al. (2007) controlled for total screen time (combination of total television and video game time) when testing the relation between violent video game play and aggression, they did not directly examine the association between nonviolent video game play and aggression. If there is something inherent about violent video game play that predicts increased aggression over time, then support for this hypothesis would be bolstered by longitudinal findings that indicate a significant link between violent video game play and aggression, but not nonviolent video game play.

It also is important to consider the possibility that a long-term link between violent video game play and aggression may be due to their common associations with other unmeasured or "third" variables, such as intraindividual characteristics (e.g., depression, being male) and unsupportive social environments (e.g., poverty, difficulties with peers and/or parents; see Anderson et al., 2007; Ferguson, 2010, 2011; Ferguson, San Miguel, & Hartley, 2009). Anderson et al. (2007) directly tested the third variable hypothesis in their short-term longitudinal study and found that the association between violent video game play and aggression was robust to the inclusion of potential third variables such as parental involvement and gender. More recently, Ferguson (2009, 2011) has argued for the importance of testing the third variable hypothesis in media violence studies by including multiple risk factors from diverse domains, such as school, family, and peers. Boxer, Huesmann, Bushman, O'Brien, and Moceri (2009) as well as Ybarra et al. (2008) provide examples of cross-sectional studies that found that violent media exposure in general (including Internet, television, video games, etc.) had a unique association with aggression, even when tested simultaneously with other risk factors for aggression. Locating violent video game exposure in particular in a broader third variable framework is critical. To address this issue, in the present study we included a diverse set of risk factors that have been found in past studies to be predictive of aggression and video game play (e.g., gender, parental education, number of at-risk background factors, number of computers in the home, depressive symptoms, peer deviance, sports involvement, academic marks, delay of gratification, friendship quality, parental relationship quality, and school culture; Anderson et al., 2007; Boxer et al., 2009; Ferguson, 2011; Hopf et al., 2008; Huesmann et al., 2003; Möβle, Kleimann, Rehbein, & Pfeiffer, 2010; Willoughby, 2008; Ybarra et al., 2008). Our confidence in the robustness of the relation between violent video games and aggression would be strengthened if analyses included these potential third variables as covariates and specifically assessed whether the link between violent video game play and aggression holds up after controlling for these variables.

The Present Study

It is clear that there is a dearth of research on the long-term relation between violent video game play and aggression. Most important, nothing is known about the association between sustained violent video game play over many years and aggressive behavior. Furthermore, the few longitudinal studies that have been conducted on the relation between violent video games and ag-

gression have been limited in several ways, including a focus only on the unidirectional effect of influence from video games to aggression (rather than considering bidirectional relations), problems with the measurement of violent video games, failing to isolate the effect of violent video game play, and including only a limited number of potential third variables as covariates.

In the present study, we sought to address these limitations with a focus on two main goals. First, adolescents were surveyed about their video game play and aggressive behaviors each year of high school (i.e., Grades 9 through 12) so that we could assess the link between sustained violent video game play across the high school years and adolescents' trajectories of aggressive behavior over the same period of time. Given findings from short-term longitudinal studies (e.g., Anderson et al., 2007), we anticipated that higher levels of sustained violent video game play would be associated with steeper increases in aggression over time than lower levels of sustained violent game play. Second, we simultaneously assessed the socialization and selection hypotheses. Past findings directly comparing these hypotheses have indicated mixed results (i.e., Anderson et al., 2007; Möller & Krahé, 2009); therefore, our expectation for this analysis was less clear. Importantly, in each of these analyses, nonviolent video game play was used as a covariate (thus allowing us to isolate the relation between violent video games and aggression) along with a comprehensive set of potential third variables, including gender, parental education, number of at-risk background factors, number of computers in the home, academic marks, depressive symptoms, delay of gratification, peer deviance, sport involvement, friendship quality, parental relationship quality, and school culture. Finally, given that boys are more likely to play violent video games than girls, we also assessed whether gender was a significant moderator of the results.

Method

Participants

Students from eight high schools encompassing a school district in Ontario, Canada, took part in the study. This study was part of a larger cohort-sequential project examining youth lifestyle choices across the high school years (e.g., Willoughby & Hamza, 2011). In the larger study, surveys were completed five times between 2003 and 2008, with some students starting the study in 2003 and others starting the study in 2004. The analyses for the present study are based on the cohort of students who entered the study in Grade 9 in 2004 and completed the survey in Grades 9, 10, 11, and 12, as this was the only cohort that were surveyed on all the measures pertinent to the study (i.e., a Likert-type scale distinguishing between the frequency of violent and nonviolent video game play was included only in the 2007 and 2008 surveys when this cohort of students was in Grade 11 and Grade 12, respectively). The overall participation rate ranged from 83% to 86% across the four waves; nonparticipation was due to student absenteeism (average of 13.5%), parental refusal (average of .06%), or student refusal (average of 1.4%). Student absenteeism from class was due to illness, a co-op placement, a free period, or involvement in another school activity. Consistent with the broader Canadian population (Statistics Canada, 2001), 92.4% of the participants were born in Canada; the most common ethnic backgrounds reported other than Canadian were Italian (31%), French (18%), British (15%), and German (12%). Data on socioeconomic status indicated that mean levels of education for mothers and fathers fell between "some college, university or apprenticeship program" and "completed a college/apprenticeship/technical diploma." Furthermore, 70% of the respondents reported living with both birth parents, 12% with one birth parent and a stepparent, 15% with one birth parent (mother or father only), and the remainder with other guardians (e.g., other relatives, foster parents, etc.).

Only students who completed the survey at a minimum of two time points over the four waves were included, resulting in 1,492 participants (50.8% female) or 84% of the total sample of 1,771 adolescents. Participants who completed the survey only in Grade 9 reported significantly less positive scores than the longitudinal participants on all the measures with the exception of the video game play ($p < .001$; mean differences ranged from .08 for friendship quality to .41 for academic marks; η^2 values ranged from .003 for friendship quality to .21 for academic marks).[1]

Procedure

Active informed assent was obtained from the adolescent participants. A letter outlining the study was mailed to the parents at each student's home prior to the survey administration; this letter indicated that parents could request that their adolescent not participate in the study. An automated phone message about the study also was left at each student's home phone number. This procedure was approved by the participating school board and the university research ethics board. The questionnaire was administered to students in classrooms by trained research staff at all time periods. Students were informed that their responses were completely confidential.

Measures

Means and standard deviations for the measures are provided in Table 1. All measures other than the third variables were assessed across all four grades of high school (i.e., Grades 9 through 12) unless otherwise indicated. Given that we controlled for the third variables in three separate analyses in which the start point was either Grade 9 or Grade 11, the third variable measures that were included in the present study were assessed both in Grade 9 and Grade 11.

Demographic factors. Single-item questions were used to assess participant sex and the number of computers in the home. Parental education was an average of two items (one per parent,

[1] There were missing data because some students did not finish the entire questionnaire (10.6% of the data, consistent with other longitudinal survey studies; e.g., Ciarrochi, Leeson, & Heaven, 2009; Feldman, Masyn, & Conger, 2009; Hyde & Petersen, 2009). To ensure that any missing data were missing at random, we included three versions of the survey at each time period so that the same scales were not always near the end of the survey. For multi-item scales, composite scores were computed for participants who responded to at least 50% of the relevant items. A second source of missing data occurred across waves due to absenteeism. As missing data were not dependent on the values of the study measures, it is reasonable to assume that these data are missing at random (R. J. A. Little & Rubin, 2002; Schafer & Graham, 2002). Missing data were imputed using the multiple imputation procedure with 100 data sets (T. D. Little, in press; Schafer & Graham, 2002).

Table 1
Means and Standard Deviations of Main Study Measures and Demographic Variables

Variable	Scale range	Grade 9 *M* (*SD*)	Grade 10 *M* (*SD*)	Grade 11 *M* (*SD*)	Grade 12 *M* (*SD*)
Gender	1–2	50.8% female			
Parental education	1–6	3.27 (1.03)			
Number of computers in home		3.09 (0.91)			
Frequency of VG play	1–5	2.24 (1.13)	2.13 (1.11)	1.94 (1.06)	1.92 (1.10)
Aggression	1–4	1.63 (0.51)	1.59 (0.51)	1.63 (0.50)	1.67 (0.48)
Sustained nonviolent VG play	0–1	0.37 (0.40)			
Sustained violent VG play	0–1	0.44 (0.35)			
Nonviolent VG play	0–1	0.36 (0.48)	0.36 (0.48)	0.39 (0.49)	0.31 (0.48)
Violent VG play	0–1	0.42 (0.50)	0.41 (0.49)	0.45 (0.50)	0.38 (0.49)
Frequency of nonviolent VG play	1–5			1.36 (0.55)	1.33 (0.49)
Frequency of violent VG play	1–5			1.69 (0.88)	1.68 (0.85)

Note. VG = video game. Violent and nonviolent video game play were measured as 0 = do not play; 1 = play.

r = .58). Higher scores indicated female gender (1 = *male*, 2 = *female*), more computers in the home, and greater parental education (1 = *did not finish high school* to 6 = *professional degree*). At-risk background was assessed by counting the number of risk factors that participants reported (i.e., participants were asked to indicate *yes* or *no* to whether they had a learning disability, were living or have lived in foster care, started using marijuana prior to age 13, had parents/guardians who engage in narcotic use, had a mother who became pregnant during her teenage years, or had parents who divorced).

Direct aggression. Direct aggression was assessed at each of the four time periods with a composite of two scales. One scale (T. D. Little, Jones, Henrich, & Hawley, 2003) assessed overt aggression with nine items (e.g., "If others have angered me, I often hit, kick, or punch them") based on a 4-point scale (1 = *not at all true of me* to 4 = *completely true of me*), with Cronbach's alphas ranging from .88 to .94 from Grades 9 to 12. The other scale (Marini, Spear, & Bombay, 1999) assessed overt aggression in the past year with four items (e.g., "How often have you pushed and shoved someone during the last school year?") based on a 5-point scale, recoded to fit a 4-point scale (1 = *never* to 4 = *every day*), with Cronbach's alphas ranging from .85 to .86 from Grades 9 to 12. A composite score was formed by averaging the overall raw scores on the two scales (correlations between the two measures were .53, .49, .49, and .44 in Grades 9 through 12, respectively). Higher composite scores indicated a higher frequency of aggression.

Violent video game play. Prevalence of violent video game play was assessed at each of the four time periods. Participants were asked to indicate *yes* or *no* to whether they played action (e.g., *God of War*) or fighting (e.g., *Mortal Kombat*) video games. After consulting with professionals in the industry, these video game categories were chosen because all games in these categories contain violence. Other categories such as strategy games were not included, as some strategy games involve violence (e.g., *Rainbow Six*), while others do not (e.g., *Civilization*). An index of sustained violent video game play was created by calculating the ratio of number of waves in which the participant reported playing either action or fighting video games to the total number of waves that the participant completed. This index ranged from 0 (*never played violent video games during any of the high school grades*) to 1 (*played violent video games during all of the high school grades*). When participants were in Grades 11 and 12 only, frequency of violent video game play also was assessed, and computed as an average of two items: "On an average day, how often do you play action games?" and "On an average day, how often do you play fighting games?" (based on a 5-point scale: 1 = *not at all* to 5 = *5 or more hr*). Higher composite scores indicated a higher frequency of violent video game play.

Nonviolent video game play. Prevalence of nonviolent video game play was assessed at each of the four time periods. Participants were asked to indicate *yes* or *no* to whether they played puzzle, art, building model worlds (e.g., *Sims*), or quiz video games. After consulting with professionals in the industry, these categories were selected because all games in these categories do not contain violence. Other categories such as sports games were not included; although some sports games do not contain any violence (such as golf or baseball games), others are violent (such as football or hockey games). Sustained nonviolent video game play represented the ratio of the number of waves in which the participant reported playing at least one of these video games to the total number of waves that the participant completed. The measure ranged from 0 (*did not play nonviolent video games during any of the high school grades*) to 1 (*played nonviolent video games during all of the high school grades*). In Grades 11 and 12 only, frequency of nonviolent video game play also was assessed and computed as an average of four items: "On an average day, how often do you play puzzle, art, building model worlds, or quiz video games?" (based on a 5-point scale: 1 = *not at all* to 5 = *5 or more hours*). Higher composite scores indicated a higher frequency of nonviolent video game play.

Overall video game play. Overall frequency of video game play was assessed at each of the four time periods and was an average of two items: "How many hours do you spend playing video games on an average school day?" and "How many hours do you spend playing video games on an average weekend?" (based on a 5-point scale: 1 = *not at all* to 5 = *5 or more hours*). Higher scores indicated a higher frequency of gaming.

Academic marks. Participants were asked to report their typical school marks for the past year based on a 5-point scale (1 = *below 50%* to 5 = *80% or higher*).

Depressive symptoms. Depressive symptoms were measured using the Center for Epidemiological Studies Depression Scale (Radloff, 1977). Participants indicated how often they experienced 20 symptoms (e.g., "I could not get going") over the past 2 weeks, using a 4-point scale (1 = *never* to 4 = *always*). Cronbach's alphas were .89 in Grade 9 and .90 in Grade 11.

Delay of gratification. Delay of gratification was measured with five items (e.g., "I have difficulty saving money to buy something several weeks later"), based on a 5-point scale (1 = *never* to 5 = *usually*). Higher scores indicated more difficulty delaying gratification. Cronbach's alphas were .75 in Grade 9 and .80 in Grade 11.

Peer deviance. Peer deviance was assessed with 10 items (e.g., "In the past year, how many of your close friends have used alcohol?") that were responded to on a 5-point scale (1 = *none of them* to *5 = all of them*). Cronbach's alphas were .90 in Grade 9 and .92 in Grade 11.

Sports involvement. Sports involvement was measured with two items ("How often in the last month have you played organized sports in school?" and "How often in the last month have you played organized sports outside of school?"), based on a 5-point scale (1 = *every day* to 5 = *never*). The correlation between the two items was .43 in Grade 9 and .54 in Grade 11.

Friendship quality. Quality of relationships with friends was measured with 18 items (e.g., "I like to get my friends' points of view on things I'm concerned about") adapted from the Inventory of Parent and Peer Attachment (Armsden & Greenberg, 1987). Items were responded to on a 4-point scale (1 = *almost never or never* to 4 = *almost always or always*). Cronbach's alphas were .84 in Grade 9 and .85 in Grade 11.

Parent–adolescent relationship quality. Parental relationship quality was measured by 17 items from the Inventory of Parent and Peer Attachment (Armsden & Greenberg, 1987). Participants completed this scale for both mother and father. Items (e.g., "My father helps me to talk about my difficulties") were responded to on a 4-point scale (1 = *almost never or never* to 4 = *almost always or always*). Cronbach's alphas for mother were .87 in Grade 9 and .86 in Grade 11, and for father were .88 in Grade 9 and .84 in Grade 11. The overall correlation between the mother and father scales was .62 in Grade 9 and .63 in Grade 11.

Parental control. Parental control was measured with six items (Stattin & Kerr, 2000) that assessed the extent to which parents imposed restrictions and required information about adolescent's activities and whereabouts (e.g., "Do you need your parent's permission to stay out late on a weekday evening?"). Items were responded to on 4-point scale (1 = *almost never or never* to 4 = *almost always or always*). Cronbach's alphas were .88 in Grade 9 and .88 in Grade 11.

School culture. School culture was assessed on the basis of 18 items from Kelly et al. (1986) relating to perceptions of opportunities for school involvement, peer behavioral values, and instructional management (e.g., "The rules in my school are strongly enforced"; "Most students in my school are well-behaved even when the teaching is not watching"), using a 5-point scale (1 = *strongly disagree* to 5 = *strongly agree*). Cronbach's alphas were .81 in Grade 9 and .89 in Grade 11.

Results

Preliminary Analyses

Table 1 outlines the means and standard deviations for the study variables. The correlations between the main study variables that were assessed across each year of high school (e.g., frequency of overall video game play, frequency of aggression, sustained violent and nonviolent video game play, dichotomous measure of violent and nonviolent video game play) are reported in Table 2. The correlations between the main study variables that were only assessed in Grades 11 and 12 (e.g., frequency of violent and nonviolent video game play) are reported in Table 3. Overall, the

Table 2
Correlation Table for the Main Study Variables for Grades 9 through 12

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Frequency of overall VG play 9	—																	
2. Frequency of overall VG play 10	.61	—																
3. Frequency of overall VG play 11	.57	.64	—															
4. Frequency of overall VG play 12	.52	.62	.69	—														
5. Aggression 9	.21	.13	.18	.17	—													
6. Aggression 10	.27	.25	.23	.21	.51	—												
7. Aggression 11	.16	.17	.17	.15	.49	.56	—											
8. Aggression 12	.21	.30	.29	.28	.50	.52	.72	—										
9. Sustained nonviolent VG play	.17	.20	.22	.16	−.09	−.06	−.13	−.11	—									
10. Sustained violent VG play	.55	.59	.62	.58	.21	.29	.23	.34	.13	—								
11. Nonviolent VG play 9	.12	.06	.04	.03	−.09	−.06	−.10	−.13	.70	.00	—							
12. Nonviolent VG play 10	.08	.17	.10	.07	−.06	−.05	−.11	−.09	.75	.04	.38	—						
13. Nonviolent VG play 11	.20	.23	.32	.24	−.05	−.01	−.06	−.04	.67	.18	.27	.43	—					
14. Nonviolent VG play 12	.21	.26	.33	.38	.03	.05	−.01	.05	.61	.26	.26	.39	.51	—				
15. Violent VG play 9	.48	.43	.44	.43	.19	.27	.20	.26	.05	.81	.02	−.01	.08	.16	—			
16. Violent VG play 10	.47	.57	.51	.50	.16	.24	.18	.26	.11	.83	.01	.09	.14	.22	.56	—		
17. Violent VG play 11	.49	.56	.61	.54	.16	.27	.23	.31	.13	.81	−.02	.04	.27	.27	.54	.62	—	
18. Violent VG play 12	.49	.54	.59	.66	.18	.20	.14	.26	.17	.79	.04	.09	.21	.43	.54	.65	.69	—

Note. VG = video game. Violent and nonviolent video game play were measured as 0 = do not play; 1 = play; 9 = Grade 9; 10 = Grade 10; 11 = Grade 11; 12 = Grade 12. Any correlation .06 or higher is significant at $p < .05$.

Table 3
Correlation Table for the Main Study Variables From Grades 11 and 12

Variable	1	2	3	4	5	6
1. Frequency of nonviolent VG play 11	—					
2. Frequency of non-violent VG play 12	.40***	—				
3. Frequency of violent VG play 11	.49***	.20***	—			
4. Frequency of violent VG play 12	.25***	.48***	.63***	—		
5. Aggression 11	.06	.02	.22***	.11*	—	
6. Aggression 12	.06*	.12**	.29***	.26***	.60***	—

Note. VG = video game. 11 = Grade 11; 12 = Grade 12.
* $p < .05$. ** $p < .01$. *** $p < .001$.

correlations between aggression and violent video game play were small (i.e., in the .20 range). In contrast, the correlations between aggression and nonviolent video game play were trivial (i.e., mostly less than .10). These correlations suggest that it is violent video game play rather than nonviolent game play that is more strongly linked to aggression. We also examined mean differences in the video game and aggression measures as a function of gender. A significant multivariate main effect was found for each grade (all Wilks's λs $< .001$; η^2 ranging from .34 in Grade 11 to .50 in Grade 9). Overall, in comparison to girls, boys reported greater frequency of overall video game play, violent video game play, and aggression, while girls reported more nonviolent video game play than boys.

Long-Term Association between Sustained Violent Video Game Play and Aggression

Analyses were conducted using latent growth curve modeling in MPlus (Version 6.0; Muthén & Muthén, 1998–2010). All measures showed acceptable skewness and kurtosis, with the exception of the number of at-risk background factors and frequency of nonviolent video game play in Grades 11 and 12. Given the nonnormality of the number of at-risk background factors and frequency of nonvideo game play measures, we used maximum-likelihood estimation with robust standard errors (MLR), a procedure that is robust to nonnormality (see Muthén & Muthén, 1998–2010). When using the multiple imputation procedure with MLR, an average MLR chi-square and standard deviation is calculated across imputations. These chi-square values are corrected using the scaling correction factor. Overall model fit was evaluated using the comparative fit index (CFI), and the root-mean-squared error of approximation (RMSEA; Bentler, 1995). As recommended by Hu and Bentler (1999), CFI values greater than .95 and RMSEAs less than .07 (simultaneously) were used as the criteria for a well-specified model.

Univariate growth trajectory of aggression. Latent growth curve modeling was used to estimate individual trajectories of aggressive behavior across the four grade levels. Two latent factors were estimated: intercept or starting point and slope or rate of change over time. We first identified a linear growth model with the intercept factor loading set to 1 at all time points, and the slope factor loading set to 0 (Grade 9), 1 (Grade 10), 2 (Grade 11), and 3 (Grade 12). A covariance was specified between the intercept and slope factors. The linear model provided a good fit for the data, $\chi^2(5) = 20.01$, $p < .01$; CFI = .98; RMSEA = .045 (.025–.066), indicating a linear increase in aggression over time, as well as significant variability in the slope. We next identified a shape model to assess nonlinear change, where the slope factor loadings were set to 0 at Grade 9 and 1 at Grade 12, and freely estimated at Grades 10 and 11. The shape model did not provide a good fit for the data. The linear model, therefore, was retained for all subsequent analyses.

Association between aggression and sustained violent and nonviolent video game play. To assess whether sustained violent and/or nonviolent video game play across the high school years independently predicted aggression, we specified paths from sustained violent video game play and sustained nonviolent video game play to the slope of the aggression trajectory. Note that the direction of effects between sustained video game play and aggression could not be ascertained in this model as sustained violent video game play was not clearly occurring prior to changes over time in aggression. The covariances among sustained violent, nonviolent video game play, and the intercept of aggression also were estimated. Model fit was good, $\chi^2(9) = 65.80$, $SD = 14.30$; CFI = .966, RMSEA = .065 ($SD = 0.008$). Sustained violent video game play significantly predicted the slope of aggression ($\beta = .18$, $p < .01$), such that participants who reported higher sustained violent video game play also had steeper increases in aggression scores over time than participants who reported less sustained violent video game play. Sustained nonviolent video game play, in contrast, did not significantly predict aggression scores ($\beta = -.05$, $p > .05$).

Association between aggression and sustained violent and nonviolent video game play when controlling for frequency of overall video game play. Because our index of sustained violent and nonviolent video game play did not account for the frequency with which participants played, it was important to assess whether the associations among aggression and sustained violent or nonviolent video game play remained significant after controlling for frequency of overall video game play over time. Therefore, we added to the model a growth trajectory for frequency of overall video game play across the four time points. As with the growth model for aggression, two latent factors (intercept and slope) were estimated for the overall video game play trajectory. Initially, a linear growth model was identified with the intercept factor loading set to 1 at all time points, and the slope factor loading set to 0 (Grade 9), 1 (Grade 10), 2 (Grade 11), and 3 (Grade 12). A covariance was specified between the intercept and slope factors. The linear model provided a good fit for the

data, $\chi^2(5) = 11.84$, $p < .05$; CFI = .994; RMSEA = .030 (.007–.053). We next identified a shape model to assess nonlinear change, where the slope factor loadings were set to 0 at Grade 9, 1 at Grade 12, and freely estimated at Grades 10 and 11. The shape model was a significantly better fit than the linear model, χ^2_{diff} (2) = 10.40, $p < .01$ [CFI = 1.00, RMSEA = .000 (.000–.033); therefore, the shape model for overall video game play was used in all subsequent analyses. The shape model indicated a decrease in video game play over time, and significant variability in the slope.

We next added paths from the intercept of aggression to the slope of overall video game play, from the intercept of overall video game play to the slope of aggression, and from sustained violent video game play and sustained nonviolent video game play to the slope of overall video game play (in addition to the existing paths from sustained violent and nonviolent video game play to the slope of aggression; see Figure 1). Covariances were estimated between the intercepts of overall video game play and aggression, between the error terms for the slopes of video game play and aggression, and between the error terms for the frequency of overall video game play and aggression within each grade (e.g., between overall video game play in Grade 9 and aggression in Grade 9). The covariances between sustained violent video game play, sustained nonviolent video game play, and the intercepts of frequency of overall video game play and aggression also were estimated. For overall video game play, the slope factor loadings for Grades 10 and 11 were fixed to the values estimated in the

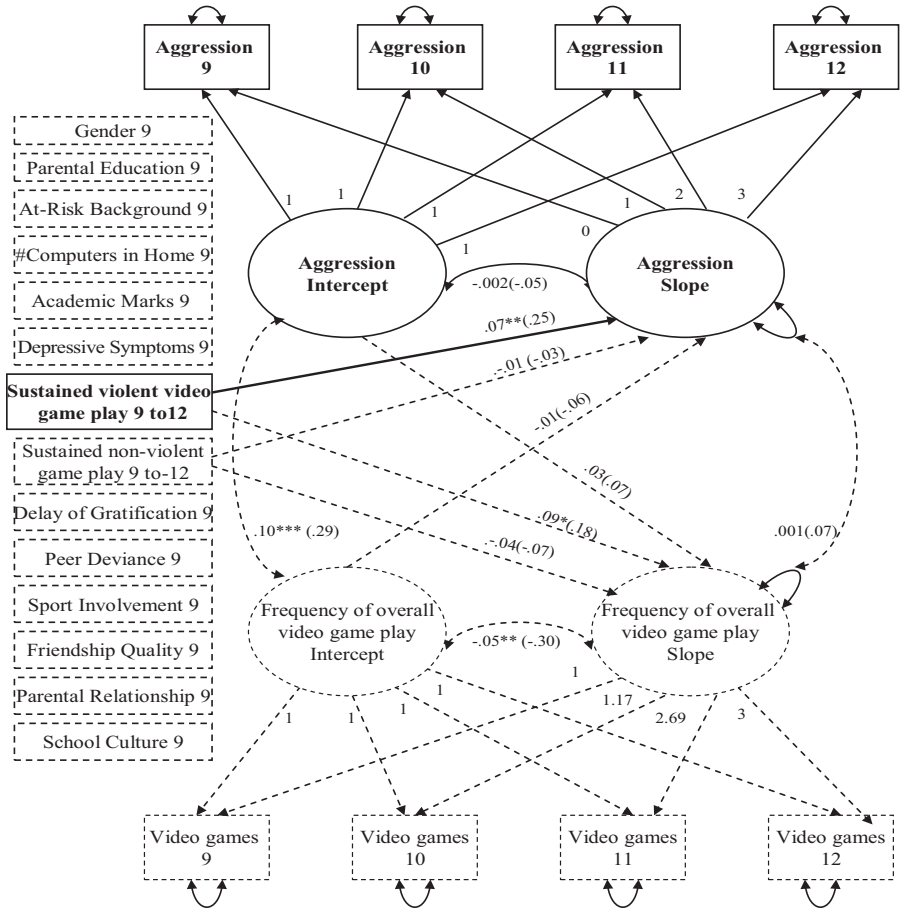

Figure 1. Final model results for analysis assessing the long-term association between sustained violent video game play and aggression. 9 = Grade 9; 10 = Grade 10; 11 = Grade 11; 12 = Grade 12. Control variables (and paths related to control variables) are indicated with dashed lines. Note that the direction of effects between sustained violent video game play and aggression cannot be ascertained in this model, as sustained violent video game play is not clearly occurring before changes over time in aggression. Not shown are paths from third variables to slopes of aggression and frequency of video game play; covariances between Grade 9 exogenous variables, and intercepts; and covariances between residuals for aggression and frequency of video game play within each grade (e.g., aggression 9 with video games 9). Unstandardized and standardized (in parentheses) coefficients are reported. *** < .001. ** < .01. * < .05. Covariance between sustained violent video game play and sustained nonviolent video game play = .02***(.13); covariances between sustained violent video game play and intercepts = .04***(.27) for aggression and .25***(.69) for video game frequency; between sustained nonviolent video game play and intercepts = −.02 (−.11) for aggression and .07***(.23) for video game frequency. Results for third variables can be obtained from the first author.

univariate growth trajectory model. Model fit was good, $\chi^2(26) = 131.14$ ($SD = 18.43$), CFI = .978, RMSEA = .052 ($SD = 0.005$). Even after controlling for frequency of overall video game play, sustained violent video game play continued to positively predict the slope of aggression ($\beta = .25$, $p < .05$).

Association between aggression and sustained violent and nonviolent video game play when adding third variables. To test whether the associations between sustained violent video game play and aggression would be robust after controlling for the third variables, we next added paths from gender, parental education, number of computers in the home, number of at-risk background factors, academic marks, depressive symptoms, delay of gratification, involvement in sports activities, peer deviance, friendship quality, parental relationship quality, parental control, and school culture (all measured in Grade 9) to the slope of aggression as well as the slope of overall video game play. Covariances among all the control variables, intercepts, sustained violent and nonviolent video game play also were estimated. Model fit was good, $\chi^2(78) = 252.70$ ($SD = 25.49$), CFI = .971, RMSEA = .039 ($SD = 0.003$). Sustained violent video game play ($\beta = .25$, $p = .01$) remained a significant predictor of the slope of aggression when controlling for the third variables. A summary of the significant results is presented in Figure 1.

Assessment of the Socialization and Selection Hypotheses

Our second and third set of analyses simultaneously assessed the socialization (playing violent video games precedes an increase in aggression) and selection (aggression precedes an increase in violent video game play) hypotheses, using autoregressive cross-lagged models. We first tested the direction of effects with our dichotomous measure of violent and nonviolent video game play (i.e., yes or no) from Grades 9 to 12. Second, we tested the direction of effects with our Likert scale measure of the frequency of violent and nonviolent video game play in Grades 11 and 12.

Association between aggression and violent video game play from Grades 9 through 12. This model was composed of three variables (violent video game play [yes/no], nonviolent video game play [yes/no], and frequency of aggression) measured from Grades 9 through 12. Bidirectional paths were estimated between violent video game play and aggression, and between nonviolent video game play and aggression. Stability paths across grade within each variable also were specified, as well as covariances among the variables within each grade. Model fit was good, $\chi^2(24) = 146.55$ ($SD = 18.33$), CFI = .979, RMSEA = .058 ($SD = 0.004$). All stability paths were significant. Playing violent video games significantly predicted higher levels of aggression from Grades 9 to 10 ($\beta = .18$, $p < .001$) and 11 to 12 ($\beta = .14$, $p < .001$), and at a trend level from Grades 10 to 11 ($\beta = .04$, $p = .06$), after controlling for stability of aggression. In contrast, playing nonviolent video games significantly predicted lower levels of aggression from Grades 10 to 11 ($\beta = -.08$, $p < .001$) and 11 to 12 ($\beta = -.05$, $p < .05$), after controlling for stability of aggression. Further, frequency of aggressive behaviors significantly predicted higher levels of violent video game play from Grades 9 to 10 ($\beta = .06$, $p < .05$) and 10 to 11 ($\beta = .10$, $p < .001$), after controlling for stability of violent video game play. Therefore, the results provide partial support for both the socialization and selection hypotheses.

Association between aggression and violent video game play from Grades 9 through 12 when controlling for frequency of overall video game play. Because our measure of violent and nonviolent video game play did not account for the frequency with which participants played, it was important to again assess whether the associations among aggression and violent or nonviolent video game play remained significant after controlling for frequency of overall video game play over time. Therefore, we added frequency of overall video game play (measured at all high school grades) to the model, and bidirectional paths were estimated from this variable to aggression, violent video game play, and nonviolent video game play at each adjacent grade. Covariances among all the variables also were estimated within each grade. Violent video game play remained a significant predictor of higher levels of aggression from Grades 9 to 10 ($\beta = .13$, $p < .001$) and 11 to 12 ($\beta = .08$, $p < .01$), even when controlling for frequency of overall video game play as well as stability in aggression. Nonviolent video game play also remained a significant predictor of lower levels of aggression from Grades 10 to 11 ($\beta = -.08$, $p < .001$) and 11 to 12 ($\beta = -.07$, $p < .01$), when controlling for frequency of overall video game play as well as stability in aggression. In contrast, frequency of aggressive behaviors only significantly predicted higher levels of violent video game play from Grades 10 to 11 ($\beta = .07$, $p < .01$), after controlling for frequency of overall video game play and stability of violent video game play.

Association between aggression and violent video game play from Grades 9 through 12 when adding third variables. Next, we tested whether the association between violent video game play and aggression was robust when controlling for the third variables. Therefore, we added the third variables (all measured in Grade 9) to the model, and paths were estimated from each of these third variables to aggression, violent video game play, nonviolent video game play, and frequency of overall video game play across all grades. Covariances among all the variables also were estimated within each grade. Playing violent video games remained a significant predictor of higher levels of aggression from Grades 9 to 10 ($\beta = .06$, $p < .05$) and from Grades 11 to 12 ($\beta = .08$, $p < .01$), and playing nonviolent video games remained a significant predictor of lower levels of aggression from Grades 11 to 12 ($\beta = -.06$, $p < .01$), even when controlling for all the third variables, frequency of overall video game play, as well as stability in aggression. In contrast, aggressive behavior in Grade 10 no longer significantly predicted higher levels of violent video game play in Grade 11 ($p > .05$). A summary of the significant results is presented in Figure 2. Overall, the socialization hypothesis was uniquely supported for violent but not nonviolent video game play, and no support was found for the selection hypothesis once the third variables and frequency of overall video game play were included in the model.

Association between aggression and frequency of violent and nonviolent video game play in Grades 11 and 12. This model was composed of three variables (frequency of violent video game play, frequency of nonviolent video game play, and frequency of aggression) measured in Grades 11 and 12. Bidirectional paths

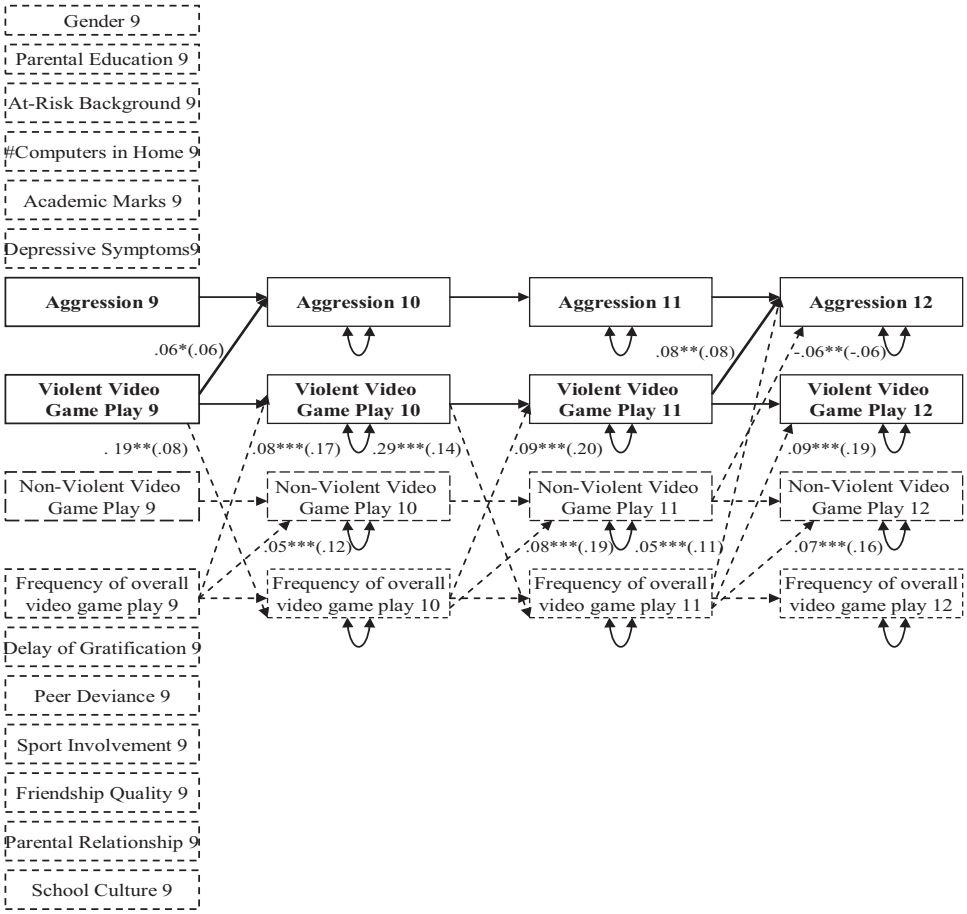

Figure 2. Final model results for analysis assessing the socialization versus selection hypotheses with dichotomous measure of violent video game play. Violent and nonviolent video game play were measured as 0 = do not play; 1 = play. 9 = Grade 9; 10 = Grade 10; 11 = Grade 11; 12 = Grade 12. Control variables (and paths related to control variables) are indicated with dashed lines. Not shown are covariances between variables within each grade and paths related to third variables. Unstandardized and standardized (in parentheses) coefficients are reported for significant paths. *** < .001. ** < .01. * < .05. Results for third variables, covariances, and stability paths can be obtained from the first author.

were estimated between frequency of violent video game play and aggression, and between frequency of nonviolent video game play and aggression. Stability paths across grade within each variable also were specified, as well as covariances among the variables within each grade. Model fit was good, $\chi^2(2) = 11.76$ (SD = 6.95), CFI = .994, RMSEA = .053 (SD = 0.022). All stability paths were significant. Frequency of playing violent video games in Grade 11 significantly predicted aggression in Grade 12 (β = .20, $p < .001$), after controlling for stability of aggression between Grades 11 and 12, such that higher frequency of playing of violent video games in Grade 11 predicted higher levels of aggression in Grade 12. In contrast, higher frequency of playing nonviolent video games in Grade 11 did not significantly predict aggression in Grade 12, after controlling for stability of aggression between Grades 11 and 12 ($p > .05$). Importantly, frequency of aggressive behaviors in Grade 11 also did not significantly predict higher levels of frequency of violent or nonviolent video game play over time (ps > .05). Therefore, the socialization hypothesis was uniquely supported for violent but not nonviolent video game play, and no support was found for the selection hypothesis.

Association between aggression and violent and nonviolent video game play in Grades 11 and 12 when adding third variables. Next, we tested whether the association between violent video game play in Grade 11 and aggression in grade 12 was robust when controlling for the third variables. Therefore, we added the third variables (all measured in Grade 11) to the model, and paths were estimated from each of these third variables to aggression in Grade 12, frequency of violent video game play in Grade 12, and frequency of nonviolent video game play in Grade 12. Covariances among all the variables also were estimated within each grade. Frequency of violent video game play in Grade 11 remained a significant predictor of aggression in Grade 12 even when controlling for the third variables as well as stability in aggression between Grade 11 and 12 (β = .12, $p < .01$). As in the model where the third variables were not included, aggressive behavior in Grade 11 did not significantly predict violent or

nonviolent video game play in Grade 12 ($ps > .05$). A summary of the significant results is presented in Figure 3.

Gender as a Moderator

Gender also was included as a moderator in each analysis. Consistent with past research (see Anderson et al., 2010), there were no significant differences in the pattern of findings as a function of gender (i.e., $ps > .05$ in χ^2_{diff} tests between constrained and unconstrained models).

Discussion

The current study is the first to demonstrate a relation between sustained violent video game play and trajectories of aggressive behavior over the entire span of high school. The first set of analyses revealed that adolescents who played violent video games across many years of high school also reported steeper increases in aggression over time compared to participants who reported less sustained play. This finding was significant even after controlling for several potentially important third variables (i.e., nonviolent video game play, overall video game play, gender, parental education, number of computers in the home, number of at-risk background factors, academic marks, depressive symptoms, delay of gratification, involvement in sports activities, peer deviance, friendship quality, parental relationship quality, parental control, and school culture), and expands on initial evidence of a 2-year longitudinal link between violent video games and aggression (e.g., Möller, & Krahé, 2009). Moreover, the standardized coefficients were in the low .20 range, suggesting a small effect, consistent with findings reported in past short-term longitudinal studies (see Anderson et al., 2010).

In the second and third set of analyses, where the socialization and selection hypotheses were assessed simultaneously, results revealed that playing violent video games (but not playing nonviolent video games) predicted higher levels of aggression over time, and greater frequency of violent video game play in Grade 11 predicted higher levels of aggression in Grade 12, even after controlling for stability in aggression as well as the third variables. In contrast, no support was found for the selection hypothesis, as frequency of aggression did not predict higher levels of violent video game play over time once the third variables were included in the models. The combined results of the three sets of analyses offer strong support for the socialization hypothesis, which suggests that violent video game play leads to increased aggressive behavior over time. Consistent with the general aggression model, violent video game play may influence an individual's level of direct aggression by promoting aggressive beliefs and attitudes and creating aggressive schema, aggressive behavioral scripts. and aggressive expectations. Importantly, gender did not moderate these results, suggesting that the link between violent video game

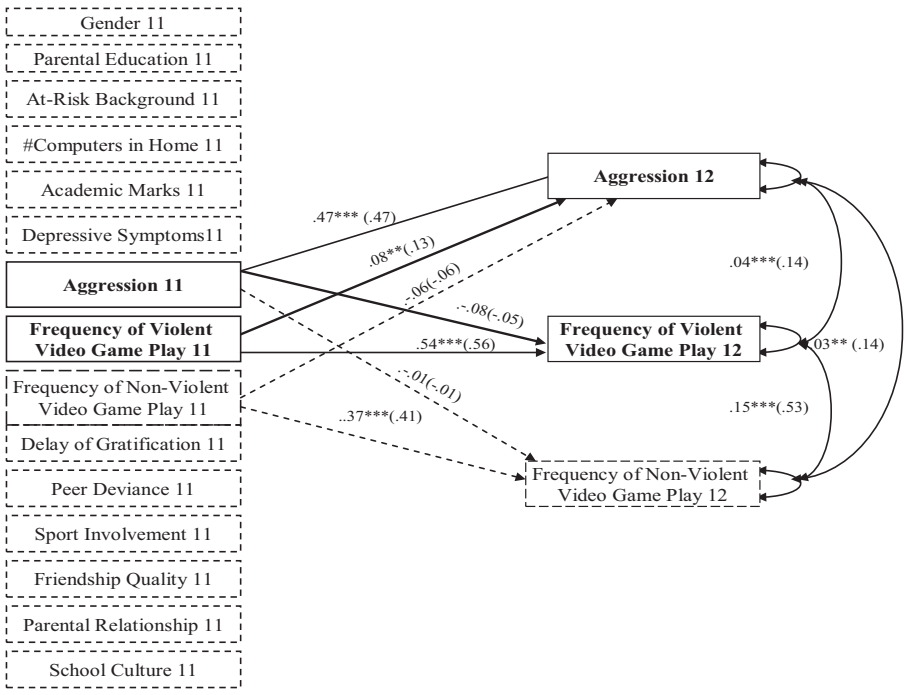

Figure 3. Final model results for analysis assessing the socialization versus selection hypotheses with frequency of violent video game play in Grades 11 and 12. 11 = Grade 11; 12 = Grade 12. Control variables (and paths related to control variables) are indicated with dashed lines. Not shown are paths from third variables to Grade 12 variables, or covariances among all Grade 11 variables. Unstandardized and standardized (in parentheses) coefficients are reported. $^{***} < .001$. $^{**} < .01$. $^{*} < .05$. Covariance between violent video game play 11 and nonviolent video play 11 = $.24^{***}(.49)$; between violent video game play 11 and aggression 11 = $.10^{***}(.22)$; and between nonviolent video game play 11 and aggression 11 = .02(.06). Results for third variables can be obtained from the first author.

play and aggression is significant for both boys and girls, consistent with the findings of other researchers (e.g., Anderson et al., 2010).

Results also support the idea that a unique relation exists between aggression and violent video game play, as opposed to nonviolent game play or frequency of gaming in general. Specifically, the association between violent game play and aggression was significant even after controlling for general video game play and the third variables, while the relation between nonviolent video game play and aggression was only significant in one of the analyses, and importantly, that relation was negative, suggesting that playing nonviolent video games in Grade 11 was associated with lower levels of aggression in Grade 12. Examining violent and nonviolent video game play separately is necessary in determining whether violent video games are uniquely related to aggressive behavior and is a major strength of the present study.

It is clear that there is a long-term association between violent video games and aggression. This is an important and concerning finding, particularly in light of the hours that youth spend playing these games. At the same time, although our results imply that playing nonviolent video games is not associated with increased aggression, our findings do not address the question of whether it is the violent content in violent video games that leads to increased aggression (see Adachi & Willoughby, 2011b, but also Anderson et al., 2010, who argued that it is the violent content of the games that is important). In fact, the nonsignificant or negative association between nonviolent video game play and aggression found in the present study may be due to the fact that nonviolent video games often differ from violent video games on several dimensions besides violence, such as competitiveness and pace of action. For example, many violent video games involve competition in the form of a battle with opponent characters (e.g., using firearms or other weaponry or hand-to-hand combat). Many nonviolent video games, however, do not involve any competition, as there often are no opponents to compete against (e.g., *Myst*, *Tetris*). Violent video games also tend to be fast-paced, whereas many nonviolent games (i.e., building model worlds, puzzles) have a much slower pace. Currently, there is no long-term longitudinal research examining the effect of video game characteristics such as competition and pace of action on aggressive behavior. More research in this area is needed.

An important limitation of the present study also stems from the reliance on self-report measures. Reports of video game use and direct aggression would benefit from corroboration from other informants (e.g., friends, parents). It is not clear, however, whether anyone other than the adolescent can provide an accurate assessment of their video game use given that much of the activity may be conducted alone. Nonetheless, the inclusion of peer assessment may be a key factor in increasing our knowledge of how often adolescents play video games with friends and peers. Another limitation with this study is that the measures did not all use the same time frame. For example, the measure of video game play assessed the number of hours participants played on an average day, while the measure of aggression assessed the frequency of behaviors in the past year. In addition, while we attempted to improve on the measurement of violent video game play in the present study, a much more precise measure is still needed. Our measure of sustained violent and nonviolent video game play also was not clearly occurring prior to changes over time in aggression, limiting our ability to assess the direction of effects between these variables.

Furthermore, the results are only generalizable to the high school population. Indeed, the long-term relation between violent video game play and aggression may be different for adolescents (e.g., 12 to 19 years) and adults (e.g., 25 years and older), due to changes in the brain during adolescence and young adulthood. Specifically, according to Steinberg (2007), puberty-related maturation of brain regions linked to emotion and arousal may lead adolescents to seek out arousing stimulation, such as risk-taking behavior. However, adolescents may have more difficulty than adults in regulating such arousal due to a still maturing prefrontal cortex (Giedd, 2008; Steinberg, 2010). Thus, adolescents may be more attracted to violent video games than adults because violent games tend to be fast-paced, exciting, and arousing. In addition, adolescents may be more likely to behave aggressively after playing a violent video game than adults, due in part to adolescents' greater difficulty in regulating their arousal in comparison to adults. Future research would benefit from direct tests of these hypotheses by examining whether the link between violent video games and aggression differs between different age groups (e.g., adolescents and adults), as well as by conducting longitudinal studies over a longer time span (e.g., from childhood to adulthood). In addition, more research is needed on potential moderators of the link between violent video game play and aggression—particularly, how the association might interact with the third variables included in this study, such as depressive symptoms and parental relationship quality. Finally, although the participants in the present study included a large sample of enrolled students from a school distinct, findings may not generalize to other geographic regions, including those with differing ethnic and/or demographic populations.

In summary, we found support for the socialization hypothesis, as participants who played violent video games throughout high school also reported steeper increases in aggressive behavior over time than participants with lower sustained playing of violent video games scores. Similarly, violent video game play predicted higher levels of aggressive behavior over time. In contrast, no support was found for the selection hypothesis, as frequency of direct aggression was not related to higher levels of violent video game play over time once the third variables were included in the model. Overall, the results offer support for the suggestion that violent video game play may be linked to greater aggression over time. The fact that many adolescents play violent video games for several hours every day (e.g., Lenhart et al., 2008) underscores the need for a greater understanding of the long-term relation between violent video games and aggression, as well as the game characteristics (e.g., violent content, level of competition, pace of action) that may be responsible for that association.

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