J Youth Adolescence (2013) 42:1090–1104
DOI 10.1007/s10964-013-9952-2

EMPIRICAL RESEARCH

Demolishing the Competition: The Longitudinal Link Between Competitive Video Games, Competitive Gambling, and Aggression

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Received: 11 March 2013 / Accepted: 11 April 2013 / Published online: 18 April 2013

Abstract The majority of research on the link between video games and aggression has focused on the violent content in games. In contrast, recent experimental research suggests that it is video game competition, not violence, that has the greatest effect on aggression in the short-term. However, no researchers have examined the long-term relationship between video game competition and aggression. In addition, if competition in video games is a significant reason for the link between video game play and aggression, then other competitive activities, such as competitive gambling, also may predict aggression over time. In the current study, we directly assessed the socialization (competitive video game play and competitive gambling predicts aggression over time) versus selection hypotheses (aggression predicts competitive video game play and competitive gambling over time). Adolescents ($N = 1{,}492$, 50.8 % female) were surveyed annually from Grade 9 to Grade 12 about their video game play, gambling, and aggressive behaviors. Greater competitive video game play and competitive gambling predicted higher levels of aggression over time, after controlling for previous levels of aggression, supporting the socialization hypothesis. The selection hypothesis also was supported, as aggression predicted greater competitive video game play and competitive gambling over time, after controlling for previous competitive video game play and competitive gambling. Our findings, taken together with the fact that millions of adolescents play competitive video games every day and that competitive gambling may increase as adolescents transition into adulthood, highlight the need for a greater understanding of the relationship between competition and aggression.

Keywords Competition · Aggression · Video games · Adolescent development · Longitudinal

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Introduction

The link between video game play and aggression, which is defined as behavior that is intended to harm another individual (Dodge et al. 2006), continues to be an important issue as games have become the fastest growing form of entertainment in the world, with a global market value of $67 billion in 2010 and a predicted value of $112 billion by 2015 (Biscotti et al. 2011). Furthermore, video game play has become ubiquitous among adolescents, as 97 % of adolescents aged 12–17 years in the United States play video games (Lenhart et al. 2008). The vast majority of research on the relationship between video game play and aggression has been focused on the effect of violent game content on elevating aggression in the short- and long-term [see Anderson et al. (2010) for a review; also see Ferguson and Kilburn (2010) for criticisms of this work]. In contrast, it has been shown recently that competition, not violence, is the main video game characteristic that influences aggressive behavior in the short-term [Adachi and Willoughby (2011a); also see Schmierbach (2010) for effects of video game competition on aggressive thoughts]. It is unclear, however, whether competition also is the driving force behind the longitudinal link between video game play and aggression, as no researchers have examined this relationship in the long-term. To date, researchers who have examined the longitudinal association between video game play and aggression have typically included video games that are both competitive and

violent, so researchers have been unable to ascertain whether it is the violence or competition that is responsible for the predictive effect on aggression (Willoughby et al. 2011). Furthermore, the direction of long-term effects between competitive video game play and aggression has not been investigated. Specifically, it is not clear whether competitive video games predict greater aggression (i.e., the socialization hypothesis) or whether individuals who are more aggressive are more likely to play competitive video games (i.e., the selection hypothesis; see Möller and Krahé 2009, for a more detailed discussion of socialization versus selection effects regarding the link between video games and aggression).

In addition, if competition is a significant reason for the longitudinal link between video games and aggression, then other activities that involve competition also may predict aggression over time. For example, gambling activities that involve competition, such as playing cards for money or betting on sports games, also may predict aggression; however, no researchers have investigated the association between competitive gambling and aggression. This is an important question because if both competitive video game play and competitive gambling (but not non-competitive video game play or non-competitive gambling) predict higher levels of aggression in the long-term, then it may be that competitive activities *in general* predict aggression over time. Thus, there may not be anything unique about the link between violent video games and aggression (i.e., because violent video games tend to be more competitive than non-violent video games). To address these questions, the goals of the current study were to examine the longitudinal, bidirectional relationship between competitive (and non-competitive) video game play and aggression, as well as between competitive (and non-competitive) gambling and aggression, using a 4-wave dataset of adolescents.

Theories of Competition and Aggression

There are several theories that explain why competition may be associated with increased aggressive behavior. According to excitation transfer theory (Zillmann 1983), the transfer of physiological arousal may be a mechanism through which competition may lead to aggression. Specifically, physiological arousal from a stimulus (e.g., competitive 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. Consistent with excitation transfer theory, in addition to elevating aggressive behavior in the short-term, competitive but not non-competitive video games have led to elevations in physiological arousal (i.e., heart rate) from baseline (Adachi and Willoughby 2011a). Competition also may influence aggression through the mechanisms of frustration and hostility, consistent with the frustration-aggression hypothesis (Berkowitz 1989; Dollard et al. 1939). For instance, when competing against another player (either a real person or a computer generated character in a video game), each player's goal of winning directly impedes the other player's chance of winning, as only one player can be victorious. Having someone constantly obstructing one's goal of winning may lead to frustration and hostility, which, in turn, may lead to elevations in aggression. In addition, competition can create or activate networks of aggressive thoughts, emotions, and memories through aggressive cues, such as feelings of frustration. Thus, consistent with Berkowitz's (1990) cognitive neoassociation model, competition may influence aggression through spreading activation of aggressive networks. In terms of longitudinal effects, repeated exposure to competitive activities such as competitive video games or competitive gambling (e.g., playing cards for money) may teach people that aggression is an appropriate way of dealing with related increases in frustration and arousal. Furthermore, a variety of past experiences with competitive situations that result in aggressive outcomes may strengthen associative links between competition and aggression (Anderson and Carnagey 2009; Anderson and Morrow 1995), which, in turn, may make long-term competitive video game players and competitive gamblers more likely to react aggressively to future competitive situations.

Developing associative links between competition and aggression also may explain why more aggressive people may be drawn to competitive situations to a greater extent than less aggressive people (selection hypothesis). According to Anderson and Morrow (1995), competitive situations often are thought of as aggressive. For example, the goal of inflicting physical or psychological harm to one's opponent in sports games and debates might be normative among competitors, as they often are encouraged to "demolish, destroy, or blow away their opponents" (Anderson and Morrow 1995, p. 1021). Furthermore, Anderson and Morrow argue that, as competitive situations occur early in life, the conceptualization of competitive situations as aggressive may occur at an early age. Thus, because competitive situations often are thought of as aggressive, more aggressive people may self select into competitive situations to a greater extent than less aggressive people.

The Link Between Video Game Play and Aggression, and Between Gambling and Aggression

Video Game Competition and Aggression

To date, the majority of research on the link between video games and aggression has been focused on the violent

content in games (e.g., see Anderson et al. 2010); however, this work has faced criticism (e.g., Adachi and Willoughby 2011b; Ferguson et al. 2008; Ferguson and Ivory 2012; Ferguson and Kilburn 2010) for issues such as not controlling for other video game characteristics that could be related to aggression, such as competition. For example, in several experiments in which a violent video game was shown to produce more aggression than a non-violent video game, the violent game also was more competitive than the non-violent game, and thus it was not clear whether the violence or competition was responsible for the elevations in aggression (e.g., Anderson and Dill 2000; Anderson et al. 2004). In addition, researchers have attempted to statistically control for differences in video game characteristics between violent and non-violent games using analysis of covariance (e.g., Anderson and Carnagey 2009). However, according to Miller and Chapman (2001), it is invalid to use analysis of covariance for preexisting groups (e.g., violent vs. non-violent video game conditions) that do not vary randomly and that differ on the variables which are to be included as the covariates. For example, when the covariate is affected by the treatment (or in this case, the condition), removing the covariate also may remove part of the treatment effect or produce a spurious treatment effect, and thus the grouping variable will be altered in a way that often cannot be specified in a conceptually meaningful way (Miller and Chapman 2001).

In order to examine whether violent or competitive content in games has a greater influence on aggressive behavior in the short-term, Adachi and Willoughby (2011a) matched video games on other characteristics that may be related to aggression. First, the violent content was isolated by matching a violent and non-violent game on competitiveness, difficulty, and pace of action—no differences were then found between the two games in terms of their effect on aggressive behavior. Thus, Adachi and Willoughby concluded that video game violence alone was not sufficient to elevate aggression. Next, competitive content was isolated by matching competitive and non-competitive games in terms of difficulty and pace of action, and systemically controlling for violence. Adachi and Willoughby found that the competitive games produced more aggressive behavior than the non-competitive games irrespective of the amount of violent content. Therefore, they concluded that competition, not violence, is the video game characteristic that has the greatest influence on aggressive behavior in the short-term.

Researchers also have demonstrated that playing a video game in a competitive context (i.e., playing against another person) influences aggressive cognition. For instance, Schmierbach (2010) used a competitive (and violent) first-person shooter game, and randomly assigned pairs of participants to one of three conditions: (a) participants played the game on their own against computer opponents (solo mode), (b) participants played against each other in a one-on-one battle (competitive mode), and (c) participants played on the same team against computer opponents (cooperative mode). Immediately after video game play, participants completed a word completion task to assess aggressive cognition. The results showed that participants in the competitive condition had the highest aggressive cognition scores, followed by participants in the solo condition, while participants in the cooperative condition had the lowest aggressive cognition scores. Thus, consistent with research showing that competitive video game content elevates aggressive behavior, playing a video game with competitive content in a competitive context (i.e., competing against another player) may further elevate aggressive cognition.

In contrast, no known researchers have examined the longitudinal relationship between competitive video game play and aggression. Instead, they have focused on the link between violent video games and aggression (e.g., Anderson et al. 2007; Möller and Krahé 2009; Wallenius and Punamäki 2008; Willoughby et al. 2011). For example, Willoughby et al. conducted a 4-year longitudinal study of adolescents in which they examined the bidirectional relationship between games that were both violent and competitive (i.e., fighting and action games) and aggression. They found evidence for the socialization hypothesis as violent and competitive video games predicted aggression over time. They also found some support for the selection hypothesis, as there was evidence that adolescents who were more aggressive tended to play violent and competitive video games more frequently. Conversely, they found that non-violent and non-competitive games (e.g., puzzle games) did not predict increased aggression over time. However, because fighting and action video games are both violent and competitive, it was unclear whether the competitive or violent content was responsible for this long-term association. Thus, in order to isolate the longitudinal relationship between video game *competition* and aggression in the current study, it is necessary to examine individuals' video game play with competitive video games that are predominately non-violent, such as sports and racing games (again, in contrast to fighting and action games which are both competitive and violent). For instance, although a few sports games contain some aggressive (but not violent) content (e.g., sports games such as football), most do not (e.g., soccer, basketball, tennis, golf, baseball, skateboarding). Similarly, while some racing games allow vehicles to come into contact with each other during a race, this behavior usually is not encouraged as it causes both vehicles to slow down or lose

control, thereby hampering their goal of winning the race. Furthermore, sports and racing games do not contain the type of violent content that can be found in many fighting, action, and first-person shooter games, such as blood-soaked battles to the death with a variety of lethal weapons.

Gambling and Aggression

Although many forms of gambling are illegal for adolescents in North America, gambling is prevalent among adolescents, as a nationally representative survey in the United States found that 68 % of youth aged 14–21 reported gambling at least once in the past year (Barnes et al. 2009). To date, there are only a few studies in which researchers have investigated a link between gambling and aggression (e.g., Parke and Griffiths 2004, 2005), or between gambling and domestic violence (e.g., Griffiths et al. 2003; Mulenman et al. 2002). For example, Parke and Griffiths (2004) conducted an observational study of aggressive behavior in slot machine players, and reported incidents of verbal aggression by the slot machine players towards staff members, other gamblers, and even towards the slot machines. However, no researchers have examined the longitudinal association between gambling and aggression. Furthermore, no researchers have separated gambling activities in terms of competitive content and then compared the effect of competitive versus non-competitive gambling activities on aggression. Similar to competitive video games, gambling activities such as playing cards for money and betting on sports games involve competition. For example, when playing poker, players must directly compete against each other during every hand, and in order to win, the other players must lose. In addition, people enter into a competition when betting on a sports game, in that in order to win their bet, the team that they bet on must defeat the opponent team (or beat the point spread, etc.). Because people who bet on sports games have a stake in the competition, they may experience similar elevations in arousal, frustration, hostility, and aggressive cognition as the athletes who are playing in the game. For instance, because a gambler's goal of winning his bet is constantly obstructed by the opponent team whose goal is to win the game, the gambler may experience elevations in frustration and hostility, and, in turn, may be more likely to behave aggressively. Hence, similar to competitive video games, competitive gambling activities may predict higher levels of aggression over time. In contrast, non-competitive gambling activities such as entering draws are based solely on luck and do not involve competition. Thus, unlike competitive gambling activities, non-competitive gambling activities may not be related to aggression over time.

The Present Study

Although experimental research has shown that competition in video games, not violence, has the greatest influence on aggression in the short-term (Adachi and Willoughby 2011a), no researchers have examined the longitudinal relationship between competitive video game play and aggression. In addition, other competitive activities, such as competitive gambling, also may predict aggression over time. No studies, however, have been conducted in which competitive and non-competitive gambling activities are separated and their respective effects on aggression compared. Furthermore, previous experimental work on the effect of competitive video games on aggression has focused solely on the unidirectional effect of competitive video games on aggression (i.e., the socialization hypothesis which represents the theory that competition causes people to be more aggressive), whereas selection effects have not been explored.

In the present study, we sought to address these questions by surveying adolescents about their video game play, gambling, and aggressive behaviors each year of high school (i.e., Grades 9 through 12). We then focused on three main goals. First, in order to examine whether competitive video game play predicts aggression over time, we used sports and racing games which are highly competitive but predominantly non-violent. Thus, if sports and racing games predict aggression over time, we can conclude that competition alone (not violence) was responsible. Consistent with experimental findings that video game competition was the game characteristic with the greatest influence on aggression in the short-term (Adachi and Willoughby 2011a), we hypothesized that competitive video game play would predict higher levels of aggression over the four high school years. In addition, in order to conclude that it was competitive video game play and not simply video game play in general that predicted aggression over time, we also examined whether playing video games that were non-competitive and non-violent (e.g., puzzle games) predicted aggression over time. In contrast to competitive video games, we hypothesized that non-competitive and non-violent video games would not predict higher levels of aggression over the four high school years.

Second, if competitive video game play predicts aggression over time, then other competitive activities also may predict aggression. Thus, we examined whether competitive forms of gambling, specifically playing card games for money and betting on sports games would predict aggression over time. Playing card games for money, such as euchre and poker, and betting on sports games, both involve entering into a competition. Therefore, similar to competitive video game play, we hypothesized that competitive gambling would predict higher levels of

aggression over time. To conclude that it was competitive gambling in particular, and not gambling in general that was related to aggression, we also examined the longitudinal link between non-competitive gambling, such as entering draws, and aggression. We hypothesized that non-competitive gambling would not predict higher levels of aggression over time.

Third, in addition to assessing the socialization hypothesis, we simultaneously assessed the selection hypothesis between competitive and non-competitive video game play and aggression, as well as between competitive and non-competitive gambling and aggression. Considering that Willoughby et al. (2011) previously found some evidence in support of both hypotheses with competitive and violent games, we predicted that more aggressive people may be more likely to play competitive video games as well as engage in competitive gambling.

To test our hypotheses, we performed a 4-wave autoregressive cross-lagged path analyses that allowed us to assess simultaneously the socialization and selection hypotheses between each variable (i.e., competitive and non-competitive video game play, and competitive and non-competitive gambling) and aggression, while controlling for stability effects as well as covariances among all the variables within each grade. Three demographic variables (gender, parental education, and number of computers in the home) were included as covariates. In addition, because the measure of competitive video game play included sports video games, and the measure of competitive gambling included betting on sports games, we wanted to rule out the possibility that adolescents who played sports video games and bet on sports games also played real sports, and that it was playing real sports that predicted higher levels of aggression over time. Thus, we included a measure of real sports involvement as a covariate at each time point to control for this potential third variable. It is important to note that real sports involvement was not a main variable of interest in our analyses because other factors besides the competition in sports may be related positively to aggression, such as physical contact (e.g., football or hockey), or negatively related to aggression, such as the fact that sports often are an organized activity that is supervised by adults.

Another possible concern may be that adolescents who play sports/racing video games also might play action/fighting (violent) video games, and thus it could be the participants' action/fighting video game play, and not their sports/racing video game play, that is driving the association with aggression. To address this issue, we examined whether the predictive effect of sports/racing games on aggression was moderated by whether participants played action/fighting games or not. If our hypothesis is correct, we would expect that the pattern of results would not differ between participants who played sports/racing games but not action/fighting games, and participants who played sports/racing games and action/fighting games. Finally, given that boys are more likely to play competitive video games than girls, we conducted an exploratory analysis to assess whether gender was a significant moderator of the results.

Methods

Participants

Students from eight high schools encompassing a school district in Ontario, Canada took part in the study in grades 9, 10, 11, and 12 (M age in grade 9 = 13 years, 10 months). This study was part of a larger cohort-sequential project. 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. 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 and the most common ethnic backgrounds reported other than Canadian was Italian (31 %), French (18 %), British (15 %), and German (12 %). Data on socioeconomic status indicated mean levels of education for mothers and fathers falling 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. There were no significant differences on any of the study measures between participants who completed the survey only in grade 9 and the longitudinal participants, $ps > .05$. Missing data resulted from absenteeism and because some students did not finish the entire questionnaire (10.6 % of the data, consistent with other longitudinal survey studies; e.g., Ciarrochi et al.

2009; Feldman et al. 2009; Hyde and Petersen 2009). 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. As missing data were not dependent on the values of the study measures, it is reasonable to assume that this data is missing at random (Little and Rubin 2002; Schafer and Graham 2002), and maximum likelihood estimation was used to estimate the models in AMOS 19 (Arbuckle 1995-2012).

Procedure

Active informed assent was obtained from the adolescent participants. Parents were provided with written correspondence mailed to each student's home prior to the survey administration outlining the study; 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. At all time periods, the questionnaire was administered to students in classrooms by trained research staff. Students were informed that their responses were completely confidential.

Measures

Means and standard deviations for the measures are provided in Table 1. All measures were assessed across all four grades of high school (i.e., Grades 9 through 12) except for gender, parental education, and number of computers in the home which were assessed in grade 9 only.

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, $r = .58$). Higher scores indicated female gender, more computers, and greater parental education (1 = did not finish high school to 6 = professional degree).

Sports Involvement

Sports involvement was measured at each of the four time points 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 = *never* to 5 = *every day*). Higher composite scores indicated higher frequency of sports involvement.

Direct Aggression

Direct aggression was assessed at each of the four time periods with a composite of two scales. One scale (Little et al. 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 et al. 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

Table 1 Means and standard deviations of study measures and demographic variables

Variable	Scale range	Grade 9 M (SD)	Grade 10 M (SD)	Grade 11 (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)			
Sports involvement	1–5	2.47 (1.17)	2.38 (1.22)	2.21 (1.19)	2.18 (0.92)
Aggression	1–4	1.63 (0.51)	1.59 (0.51)	1.63 (0.50)	1.67 (0.48)
Competitive vg	1–2	1.31 (0.38)	1.30 (0.37)	1.29 (0.39)	1.34 (0.37)
Non-competitive vg	1–2	1.34 (0.47)	1.36 (0.48)	1.39 (0.49)	1.31 (0.46)
Freq competitive gambling	1–5	1.37 (0.60)	1.55 (.79)	1.48 (0.72)	1.41 (0.76)
Freq non-competitive gambling	1–5	1.36 (0.55)	1.31 (0.65)	1.34 (0.67)	1.30 (0.70)
Freq competitive vg	1–5			1.64 (0.67)	1.46 (0.50)
Freq non-competitive vg	1–5			1.32 (0.59)	1.27 (0.55)

vg video game play, *Freq* frequency; Competitive and non-competitive video game play was measured as 1 = do no play, 2 = play

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.

Competitive Video Game Play

Prevalence of competitive video game play was assessed at each of the four time points with two items. Participants were asked to indicate *yes* or *no* to whether they played sports (e.g., *FIFA Soccer*) or racing (e.g., *NASCAR*) video games. When participants were in Grades 11 and 12 only, frequency of competitive video game play also was assessed, and computed as an average of two items: "On an average day, how often do you play sports games?" and "On an average day, how often do you play racing 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 competitive video game play.

Non-competitive Video Game Play

Prevalence of non-competitive video game play was assessed at each of the four time periods with four items. Participants were asked to indicate *yes* or *no* to whether they played puzzle (e.g., *Tetris*), art (e.g., *Printshop*), building model worlds (e.g., *Sims*), or quiz (e.g., Outburst) video games. 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.

Playing of Violent Video Games over the 4 Years (Moderator Variable)

Participants were asked to indicate *yes* or *no* to whether they played action (e.g., *Call of Duty*) or fighting (e.g., *Mortal Kombat*) video games at each time point. A dichotomous moderator variable was then created as 0 (did not play action or fighting games at any time point) and 1 (played action and fighting games during at least one time point).

Frequency of Competitive Gambling

Frequency of competitive gambling was assessed at each of the four time periods with two items. Participants were asked to indicate how often they played cards (poker, euchre) for money and bet on a sporting event (e.g., pro-line) based on a 5-point scale (1 = *never* to 5 = *every day*). Higher composite scores indicated higher frequency of competitive gambling.

Frequency of Non-competitive Gambling

Frequency of non-competitive gambling was assessed at each of the four time periods. Participants were asked to indicate how often they entered draws for charity based on a 5-point scale (1 = *never* to 5 = *every day*). Higher scores indicated higher frequency of non-competitive gambling.

Results

Preliminary Analyses

Table 1 outlines the means and standard deviations for the study variables. The correlations among the main study variables that were assessed across each year of high school (e.g., dichotomous measures of competitive and non-competitive video game play and frequency measures of competitive and non-competitive gambling, and aggression) are reported in Table 2. The correlations between the main study variables that only were assessed in Grades 11 and 12 (e.g., frequency of competitive and non-competitive video game play) are reported in Table 3.

As indicated in the correlation tables, competitive video game play was correlated moderately positively with aggression. In contrast, the correlations between non-competitive video game play and aggression were small and mostly negative. Competitive gambling also was correlated moderately positively with aggression, whereas the correlations between non-competitive gambling and aggression were small and positive. These correlations suggest that it is competitive video game play and competitive gambling rather than non-competitive video game play and non-competitive gambling, that are linked more strongly to aggression. We also examined mean differences in the video game, gambling, and aggression measures as a function of gender. A significant multivariate main effect was found at each grade (all Wilks λs $<.001$, R^2 ranging from .27, 95 % CI [.23, .31] in grade 9 to .35, 95 % CI [.31, .39] in grade 11). Overall, boys reported more aggression, competitive video game play, competitive gambling, and non-competitive gambling than girls, while girls reported more non-competitive video game play than boys. All

Table 2 Correlation table for main study variables from grades 9 through 12

Variable	1	2	3	4	5	6	7	8	9	10
1. Aggression 9	–									
2. Aggression 10	.52	–								
3. Aggression 11	.49	.56	–							
4. Aggression 12	.51	.54	.72	–						
5. Competitive vg 9	.20	.21	.20	.22	–					
6. Competitive vg 10	.21	.25	.24	.25	.49	–				
7. Competitive vg 11	.20	.27	.25	.28	.41	.51	–			
8. Competitive vg 12	.15	.19	.21	.26	.31	.34	.40	–		
9. Non-competitive vg 9	−.09	−.09	−.08	−.09	.12	−.02	−.04	−.03	–	
10. Non-competitive vg 10	−.06	−.06	−.08	−.08	−.01	.09	−.01	−.03	.35	–
11. Non-competitive vg 11	−.01	−.01	−.03	−.04	.03	.07	.25	.06	.23	.45
12. Non-competitive vg 12	.01	.02	.01	.04	.07	.10	.19	.13	.24	.41
13. Freq competitive gbl 9	.32	.25	.24	.25	.25	.22	.20	.16	−.06	−.07
14. Freq competitive gbl 10	.26	.36	.31	.37	.25	.35	.28	.19	−.09	−.11
15. Freq competitive gbl 11	.23	.32	.38	.33	.24	.27	.30	.22	−.09	−.09
16. Freq competitive gbl 12	.23	.29	.33	.35	.23	.26	.26	.30	−.09	−.09
17. Freq non-competitive gbl 9	.04	.03	.03	.02	.03	.02	.01	.01	.01	.00
18. Freq non-competitive gbl 10	.09	.22	.14	.13	.06	.08	.07	.05	−.01	.03
19. Freq non-competitive gbl 11	.09	.17	.19	.18	.09	.10	.16	.10	−.03	−.02
20. Freq non-competitive gbl 12	.09	.12	.15	.18	.08	.09	.10	.14	−.03	−.02

Variable	11	12	13	14	15	16	17	18	19	20
1. Aggression 9										
2. Aggression 10										
3. Aggression 11										
4. Aggression 12										
5. Competitive vg 9										
6. Competitive vg 10										
7. Competitive vg 11										
8. Competitive vg 12										
9. Non-competitive vg 9										
10. Non-competitive vg 10										
11. Non-competitive vg 11	–									
12. Non-competitive vg 12	.64	–								
13. Freq competitive gbl 9	−.02	.01	–							
14. Freq competitive gbl 10	−.03	.02	.40	–						
15. Freq competitive gbl 11	−.01	.04	.34	.47	–					
16. Freq competitive gbl 12	−.01	.06	.34	.44	.49	–				
17. Freq non-competitive gbl 9	.00	−.01	.24	.07	.05	.05	–			
18. Freq non-competitive gbl 10	.01	.02	.10	.38	.15	.14	.18	–		
19. Freq non-competitive gbl 11	.05	.04	.11	.19	.49	.21	.14	.31	–	
20. Freq non-competitive gbl 12	.01	.08	.10	.14	.18	.54	.11	.17	.24	–

vg video game play, *gbl* gambling, *Freq* frequency; 9 = grade 9; 10 = grade 10; 11 = grade 11; 12 = grade 12. $r = .06$ is significant at $p < .05$, $r = .07$ to .09 is significant at $p < .01$, any $r = .10$ or higher is significant at $p < .001$

measures showed acceptable skewness and kurtosis, with the exception of the competitive and non-competitive gambling measures. To address this issue, we conducted a $\log^{10}$ transformation for each gambling variable, which reduced skewness and kurtosis to acceptable levels (skewness <2 and kurtosis <3 for all variables).

Table 3 Correlation table for main study variables for grade 11 and 12

Variable	1	2	3	4	5	6	7	8	9	10
1. Aggression 11	–									
2. Aggression 12	.72	–								
3. Freq competitive vg 11	.36	.36	–							
4. Freq competitive vg 12	.35	.39	.77	–						
5. Freq non-competitive vg 11	.02	.05	.22	.13	–					
6. Freq non-competitive vg 12	.00	.06	.12	.26	.50	–				
7. Freq competitive gbl 11	.40	.39	.37	.36	.06	.04	–			
8. Freq competitive gbl 12	.33	.36	.31	.38	.04	.17	.50	–		
9. Freq non-competitive gbl 11	.21	.22	.17	.16	.11	.06	.50	.23	–	
10. Freq non-competitive gbl 12	.19	.22	.13	.19	.03	.22	.19	.54	.25	–

vg video game play, *gbl* gambling, *Freq* frequency; 11 = grade 11; 12 = grade 12. $r = .06$ is significant at $p < .05$, $r = .07$ to .09 is significant at $p < .01$, any $r = .10$ or higher is significant at $p < .001$

Assessment of the Socialization and Selection Hypotheses

Association Between Aggression, Competitive Video Game Play and Frequency of Competitive Gambling from Grades 9 Through 12

In order to assess simultaneously the socialization (playing competitive but not non-competitive video games/gambling predicts higher levels of aggression over time) and selection (aggression predicts higher levels of competitive but not non-competitive video game play/gambling over time) hypotheses, while controlling for gender, parental education, number of computers in the home, and sports involvement, we created a 4-wave (grade 9–12) autoregressive cross-lagged model in which bidirectional paths were estimated across each adjacent grade between both competitive and non-competitive video game play and aggression, and between both competitive and non-competitive gambling and aggression (see Fig. 1). Stability paths across grade within each variable also were specified, as well as covariances among the variables within each grade to control for common method variance.

We first assessed whether the pattern of results was invariant across grade. Invariance was tested by comparing a model in which all cross-lagged paths were constrained to be equal across grade to the unconstrained model in which all structural paths were free to vary. The Chi square difference test of relative fit indicated that the unconstrained model was not a significantly better fit than the constrained model, suggesting that the patterns of associations among the measures were consistent across the high school years, $p > .05$. As the constrained model was the most parsimonious model, all further interpretations were based on the constrained model. Model fit was good, $\chi^2(110) = 191.63$, $p < .001$, CFI = .99, RMSEA = .022 (.017–.028). Figure 1 summarizes the significant path estimates. In terms of the socialization hypothesis, competitive video game play significantly predicted higher aggression over time, after controlling for previous aggression. In contrast, non-competitive video game play did not significantly predict aggression over time, after controlling for previous aggression. Consistent with the relationship between competitive video games and aggression, frequency of competitive gambling also significantly predicted higher aggression over time, after controlling for previous aggression. Conversely, frequency of non-competitive gambling did not predict aggression over time, after controlling for previous aggression.

In terms of the selection hypothesis, higher levels of aggression significantly predicted competitive video game play over time, after controlling for previous competitive video game play. In contrast, aggression did not significantly predict non-competitive video game play over time, after controlling for previous non-competitive video game play. In addition, higher levels of aggression significantly predicted higher frequency of competitive gambling, after controlling for previous frequency of competitive gambling. Interestingly, higher levels of aggression also significantly predicted higher frequency of non-competitive gambling, after controlling for previous frequency of non-competitive gambling. Furthermore, we tested whether the selection effects between competitive video game play and aggression as well as between competitive gambling and aggression were stronger than the socialization effects, by comparing a model in which the paths testing the socialization and selection effects were constrained to be equal between competitive video game play and aggression as well as between competitive gambling and aggression, to a model in which the socialization and selection effects were not constrained to be equal. For both video game play and gambling, the Chi square difference test of relative fit

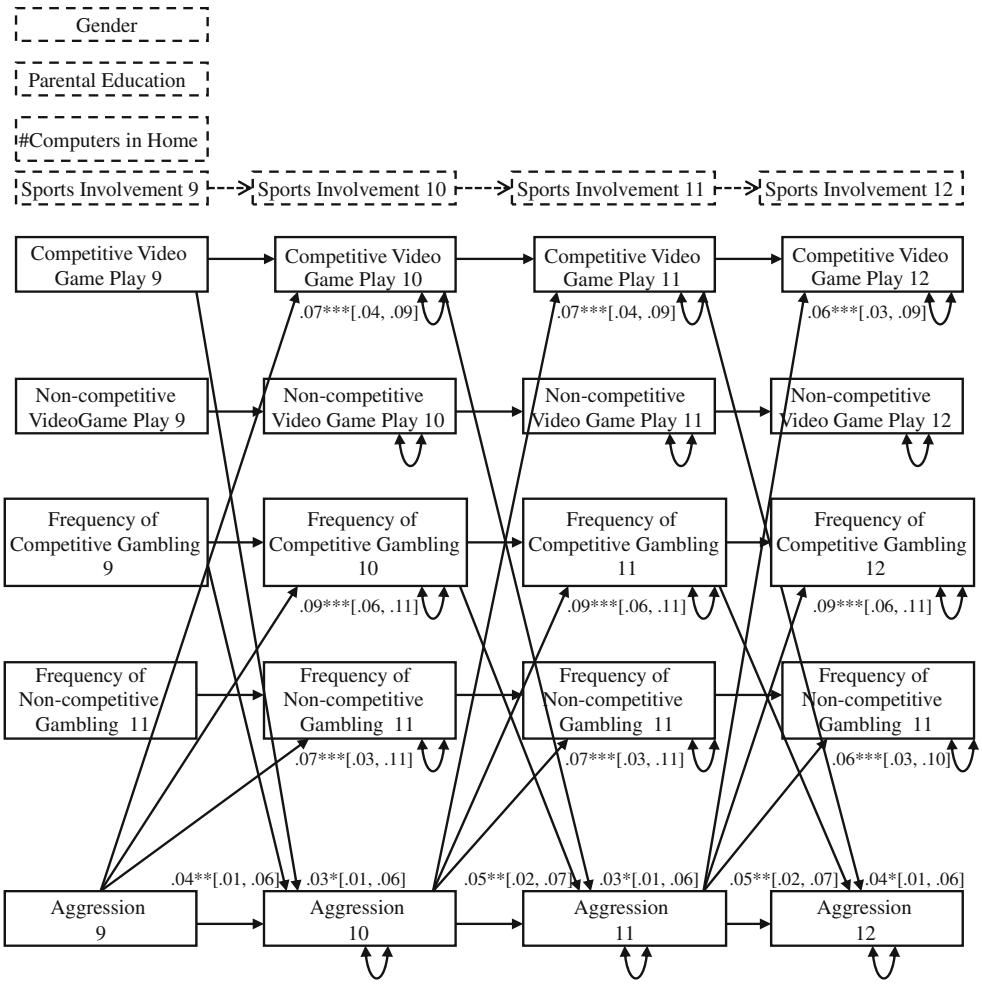

Fig. 1 Final model results for analysis assessing the socialization versus selection hypotheses with dichotomous measures of competitive and non-competitive video game play. 9 = grade 9; 10 = grade 10; 11 = grade 11; 12 = grade 12. Covariates are indicated with *dashed lines*. Only significant paths are shown. Not shown are covariances among variables within each grade, or paths related to covariates. Standardized coefficients (95 % confidence intervals are in *brackets*) are reported for significant paths. * <.05, ** <.01, *** <.001. Results for covariates, covariances, and stability paths can be obtained from the first author

indicated that the constrained and unconstrained models did not differ, suggesting that the selection versus socialization effects between competitive video game play and aggression as well as between competitive gambling and aggression were not significantly different in magnitude, $p > .05$.

Association Between Aggression and Frequency of Competitive Video Game Play and Frequency of Competitive Gambling in Grades 11 and 12

Because our measures of video game play were dichotomous (yes/no), it was important also to assess the bidirectional association between *frequency* of competitive and non-competitive video game play and aggression. To test this model, when our participants were in grades 11 and 12, they indicated the frequency with which they engaged in video game play and gambling behaviors. Five variables (frequency of competitive video game play, frequency of non-competitive video game play, frequency of competitive gambling, frequency of non-competitive gambling, and aggression) were measured in Grades 11 and 12. Bidirectional paths were estimated between each variable and aggression, and stability paths across grade within each variable also were specified, as well as covariance among the variables within each grade. Gender, parental education, number of computers in the home, and sports involvement were included as covariates. Model fit was good, $\chi^2(16) = 61.19$, $p < .001$, CFI = .99, RMSEA = .044 (.032–.055). Figure 2 summarizes the significant path estimates. In terms of the socialization hypothesis and consistent with the first model, the frequency of competitive video game play significantly predicted higher aggression over time, after controlling for previous aggression. In contrast, the frequency of non-competitive video game play did not significantly predict aggression over time, after controlling for previous aggression. The frequency of competitive gambling also significantly predicted higher aggression over time, after controlling for previous aggression. Conversely, the frequency of non-competitive gambling did not predict aggression over time, after controlling for previous aggression.

In terms of the selection hypothesis, higher levels of aggression significantly predicted higher frequency of

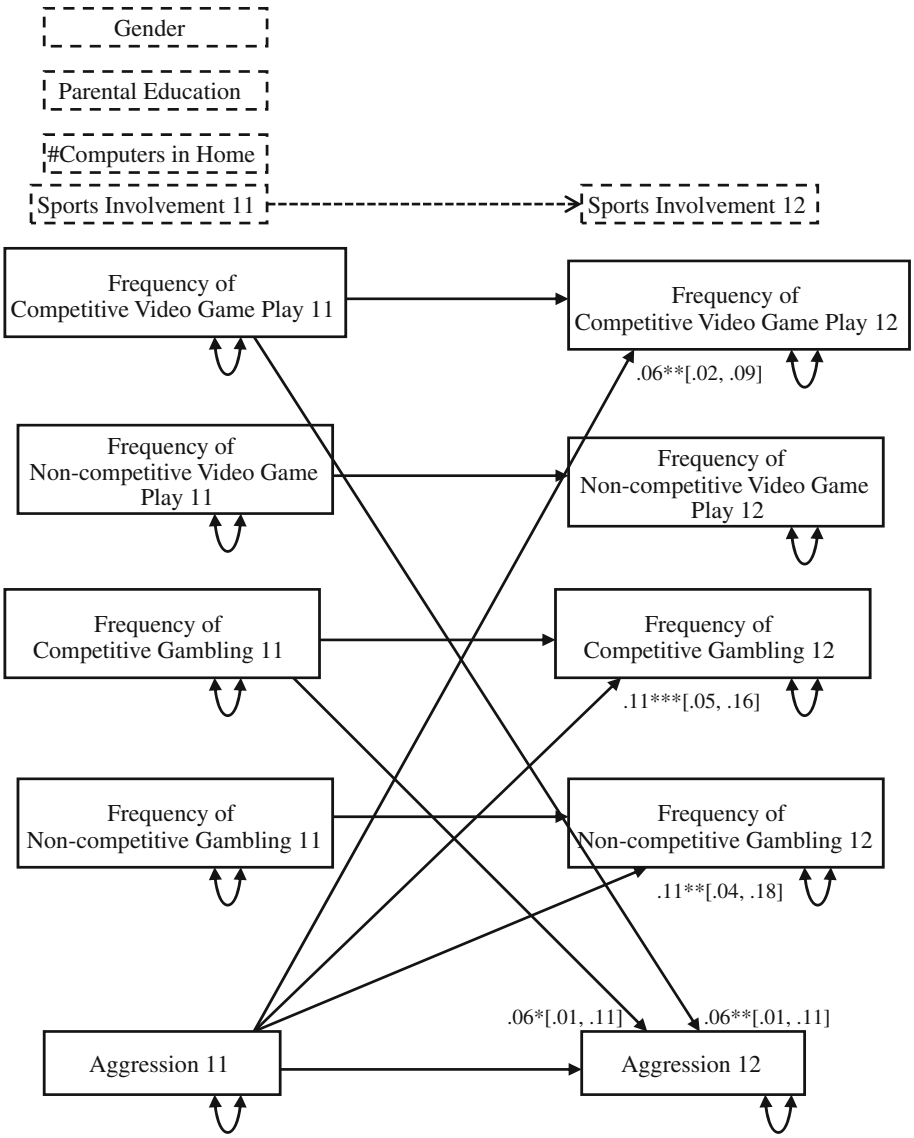

Fig. 2 Final model results for analysis assessing the socialization versus selection hypotheses with frequency measures of competitive and non-competitive video game play. 11 = grade 11; 12 = grade 12. Covariates are indicated with *dashed lines*. Only significant paths are shown. Not shown are covariances among variables within each grade, or paths related to covariates. Standardized coefficients (95 % confidence intervals are in *brackets*) are reported for significant paths. * <.05, ** <.01, *** <.001. Results for covariates, covariances, and stability paths can be obtained from the first author

competitive video game play over time, after controlling for previous competitive video game play. In contrast, aggression did not significantly predict frequency of non-competitive video game play over time, after controlling for previous non-competitive video game play. In addition, higher levels of aggression significantly predicted higher frequency of competitive gambling, after controlling for previous frequency of competitive gambling. Higher levels of aggression also significantly predicted higher frequency of non-competitive gambling, after controlling for previous frequency of non-competitive gambling. Furthermore, we tested whether the selection effects between the frequency of competitive video game play and aggression as well as between the frequency of competitive gambling and aggression were stronger than the socialization effects, by comparing a model in which the socialization and selection effects were constrained to be equal between competitive video game play and aggression as well as competitive gambling and aggression, to a model in which the socialization and selection effects were not constrained to be equal. The Chi square difference test of relative fit indicated that the model in which the selection and socialization effects were not constrained to be equal was not a significantly better fit than the constrained model, suggesting that the selection and socialization effects between frequency of competitive video game play and aggression as well as between frequency of competitive gambling and aggression were not significantly different in magnitude, $p > .05$.

Violent Video Game Play as a Moderator

Playing of action/fighting video games was included as a moderator to test whether playing sports/racing games was

associated with aggression only for participants who also played action/fighting (i.e., violent) games. Consistent with our hypotheses, there were no significant differences in the pattern of results as a function of playing action/fighting games ($p > .05$ in χ^2 *diff* tests between constrained and unconstrained models), suggesting that playing sports/racing games predicted aggression regardless of whether participants also played action/fighting games or not.

Gender as a Moderator

Gender also was included as a moderator and there were no significant differences in the pattern of findings as a function of gender ($p > .05$ in χ^2 *diff* tests between constrained and unconstrained models).

Discussion

The majority of research on the relationship between video games and aggression has focused on the violent content in games (see Anderson et al. 2010 for a review; see also Ferguson and Kilburn 2010 for criticisms of this work). In contrast, recent experimental research suggests that it is video game competition, not violence, that has the greatest effect on aggression in the short-term (Adachi and Willoughby 2011a). However, no researchers have examined the longitudinal relationship between competitive video game play and aggression. In addition, if competition in video games is a significant reason for the association between video game play and aggression, then other competitive activities, such as competitive gambling, also may predict aggression over time. The current study is the first to demonstrate a longitudinal, bidirectional association between competitive video game play and aggression, as well as between competitive gambling and aggression. Consistent with our hypotheses, the results revealed support for the socialization hypothesis in that playing competitive video games (but not non-competitive video games) as well as higher frequency of competitive gambling (but not non-competitive gambling) predicted higher levels of aggression across the four high school years. In addition, higher frequency of competitive video game play (but not non-competitive video game play) in Grade 11 predicted higher levels of aggression in Grade 12. These findings suggest that adolescents who engage in competitive video game play and competitive gambling may be more likely to behave aggressively over time. We also found support for the selection hypothesis as higher levels of aggression predicted competitive video game play as well as higher frequency of competitive gambling from Grade 9 to Grade 12, and higher levels of aggression in grade 11 predicted higher frequency of competitive video game play in Grade 12, which suggests that adolescents who are more aggressive may be more likely to self-select into these competitive activities. Furthermore, the fact that we controlled for sports involvement at each time point rules out the potential third variable explanation that people who play sports video games and bet on sports games also play real sports, and that it is the playing of real sports that predicts aggression over time.

In addition, to address the possible concern that adolescents who play sports/racing video games also might play action/fighting (violent) video games, and thus, it could be the participants' action/fighting video game play, and not their sports/racing video game play, that is driving the association with aggression, we examined whether the predictive effect of sports/racing games on aggression was moderated by whether participants played action/fighting games or not. Consistent with our hypothesis, the pattern of results did not differ between participants who played sports/racing games but not action/fighting games, and participants who played sports/racing games and action/fighting games. Thus, an important strength of the current study is that the longitudinal association between playing sports/racing games and aggression remained stable after controlling for action/fighting video game play.

The current findings are important as they elucidate a long-term relationship between competition and aggression among adolescents. First, the finding that competitive, but not non-competitive video game play, predicted aggression over time after controlling for violent video game play suggests that, in addition to having a short-term effect on aggression (Adachi and Willoughby 2011a), video game competition also predicts higher levels of aggression in the long-term. Second, the finding that competitive, but not non-competitive gambling also predicted aggression over time suggests that competitive activities in general may predict later aggression. This finding is important because if competitive activities in general predict aggression, then this suggests that there may not be something unique about the association between violent video game play and aggression. Specifically, it suggests that the longitudinal link found between violent video games and aggression (see Willoughby et al. 2011) may be due to the competition in the games, rather than the violence, as violent video games in general tend to be more competitive than non-violent games (Carnagey and Anderson 2005; Adachi and Willoughby 2011b). Thus, violent video game play may be a long-term risk factor for aggression among adolescents for the same reason that competitive video game play and competitive gambling are risk factors: because they are all *competitive* activities.

Interestingly, we also found that higher levels of aggression predicted higher frequency of non-competitive gambling (i.e., entering draws). According to Steinberg

(2007), the desire to take risks increases in adolescence, and thus many forms of risk taking increase from childhood to adolescence. Considering that aggression and gambling are both forms of risk taking, it may be that adolescents who are more aggressive also are more likely to seek out other forms of risk taking such as gambling, than adolescents who are less aggressive. Furthermore, entering draws may be one of the most accessible forms of gambling for adolescents, as draws may not be restricted to adults unlike most forms of gambling (e.g., going to the casino, playing online poker). Conversely, adolescents who enter draws may not be more likely to behave aggressively because aggression often is a much riskier activity with more severe consequences than entering draws. Specifically, when someone behaves aggressively their victim may retaliate, and thus they are at risk for being the target of aggression. Furthermore, adolescents who behave aggressively may face negative consequences at school (e.g., suspension), at home (e.g., punishment from parents), or even with the law (e.g., assault charges). In contrast, adolescents who enter draws risk losing money, which may be considered as less of a risk compared to the potential negative consequences of behaving aggressively. Thus, adolescents who are willing to enter draws may not be willing to then take larger risks, such as behaving aggressively.

Given the longitudinal relationship found between competitive activities and aggression in the present study, future research should be aimed at identifying potential mediators of this association. In terms of socialization effects, consistent with excitation transfer theory (Zillmann 1983) as well as the frustration-aggression hypothesis (Berkowitz 1989; Dollard et al. 1939), it may be that repeated exposure to competitive activities may teach people that aggression is an appropriate way to deal with related increases in frustration and arousal. Thus, researchers should examine whether frustration and arousal mediate the link between competitive activities and aggression, in that greater involvement in competitive activities may predict higher levels of frustration and arousal, and, in turn, higher levels of frustration and arousal may predict higher levels of aggression over time. In addition, researchers should examine whether sustained participation in competitive activities over time may strengthen associative links between competition and aggression, consistent with Anderson and Carnagey (2009), and Anderson and Morrow (1995), which, in turn, may lead to higher levels of aggression. Using the implicit association test (IAT), researchers could examine whether people who report greater sustained participation in competitive activities tend to demonstrate stronger implicit associations between competition and aggression than people with less sustained participation in competitive activities, and, in turn, whether these implicit associations mediate the predictive influence of competitive activity involvement on aggression. In terms of selection effects, it may be that more aggressive people are more likely to associate competitive activities with aggression, and thus are more likely to seek out competitive activities than less aggressive people. Hence, the IAT also could be used to examine whether more aggressive people tend to demonstrate stronger implicit associations between competition and aggression than less aggressive people, and, in turn, whether these implicit associations mediate the predictive influence of aggression on competitive activity involvement.

An important limitation of the present study stems from the reliance on self-report measures. Reports of video game use, aggression, and gambling 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. Importantly, however, we specified covariances among all of the variables within each time period in both models, thus accounting for common method variance. 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 was that the structural paths that were significant in the present study were all small in magnitude. However, these effect sizes are common in longitudinal cross-lagged models when accounting for stability between adjacent waves of data and for concurrent associations among variables within each grade. Thus, small effects are not unexpected. Another possible concern may be that, because a few sports and racing games might contain some aggressive content, it may be this aggressive content, rather than the competitive content, that was associated with aggression in the present study. However, we think this is unlikely given that the competitive gambling activities also had a significant association with aggression that was similar in magnitude to competitive video game play, even though gambling does not involve violence or aggression. In addition, our findings are consistent with an experiment that demonstrated that it was the competitive content rather than the violent content that influenced aggression (Adachi and Willoughby 2011a).

Furthermore, the results are generalizable only to the high school population. Indeed, the long-term relationship between competitive video game play and aggression may be different for adolescents (e.g., 12–19 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 competitive video games than adults because competitive video games tend to be fast-paced, exciting, and arousing. In addition, adolescents may be more likely to behave aggressively after playing a competitive video game than adults, due in part to adolescents' greater difficulty in regulating their arousal in comparison to adults. In contrast, the long-term relationship between competitive gambling and aggression may be stronger for young adults (age 19–25 years) than adolescents, due to differences in gambling habits between the two age groups. Specifically, playing cards for money in a casino or regulated forms of sports betting (e.g., Proline) may be more prevalent among young adults than adolescents (Felsher et al. 2010; Shaffer and Hall 2001) because these activities are illegal for adolescents in North America. Thus, if young adults engage in more competitive gambling than adolescents, then both socialization and selection effects on aggression may be stronger for young adults compared to adolescents. Future research would benefit from direct tests of these hypotheses by examining whether the link between competitive video games and aggression as well as between competitive gambling and aggression differ between 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). 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 a bidirectional association between competitive video game play and aggression as well as between competitive gambling and aggression. In terms of the socialization hypothesis, we found that both competitive video game play and competitive gambling predicted higher levels of aggression over time. In terms of the selection hypothesis, we found that higher levels of aggression predicted higher levels of competitive video game play and competitive gambling over time. Overall, the results suggest that competitive activities in general may predict aggression over time among adolescents. The fact that millions of adolescents play competitive video games for several hours every day (Lenhart et al. 2008) and competitive gambling may increase as adolescents transition into adulthood, beckons the need for a greater understanding of the relationship between competition and aggression.

Acknowledgments The second author acknowledges funding received from the Social Sciences and Humanities Research Council of Canada and the Owl Children's Trust.

Author Contributions P.A. conceived the study, conducted most of the statistical analyses, and drafted the manuscript. T.W. collected the data and participated in the statistical analyses as well as the drafting of the manuscript. All authors read and approved the final manuscript.

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Author Biographies

Paul J. C. Adachi received his MA degree in psychology from Brock University and is currently a PhD candidate. In terms of research, Paul is interested in the positive and negative effects of video games on adolescent development. He has conducted research examining the relation between video game competition and aggression, and is currently investigating the relation between video game play and cooperation.

Teena Willoughby is a professor in the Department of Psychology at Brock University. She her received her PhD in psychology from Waterloo University. Her research interest is in adolescent development, particularly with regard to risk taking, academic achievement, and media use (e.g., video game play).