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EMPIRICAL RESEARCH

The Effects of Pathological Gaming on Aggressive Behavior

Jeroen S. Lemmens · Patti M. Valkenburg · Jochen Peter

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Abstract Studies have shown that pathological involvement with computer or video games is related to excessive gaming binges and aggressive behavior. Our aims for this study were to longitudinally examine if pathological gaming leads to increasingly excessive gaming habits, and how pathological gaming may cause an increase in physical aggression. For this purpose, we conducted a two-wave panel study among 851 Dutch adolescents (49% female) of which 540 played games (30% female). Our analyses indicated that higher levels of pathological gaming predicted an increase in time spent playing games 6 months later. Time spent playing violent games specifically, and not just games per se, increased physical aggression. Furthermore, higher levels of pathological gaming, regardless of violent content, predicted an increase in physical aggression among boys. That this effect only applies to boys does not diminish its importance, because adolescent boys are generally the heaviest players of violent games and most susceptible to pathological involvement.

Keywords Pathological gaming · Game addiction · Video games · Aggression · Adolescents · Longitudinal

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Introduction

Although pathological use of computer or video games is not officially recognized as a clinical disorder, studies have consistently shown that a small group of players spend excessive amounts of time on games and display numerous symptoms of pathological behavior, such as preoccupation, withdrawal, loss of control, and interpersonal or intrapersonal conflicts (e.g., Charlton and Danforth 2007; Gentile 2009; Grüsser et al. 2007). The main difference between excessive and pathological gaming is that excessive gaming reflects behavior that is disproportionate but not necessarily problematic, whereas pathological gaming is defined as the persistent inability to control excessive gaming habits despite associated social or emotional problems (Lemmens et al. 2009). In general, adolescents are more likely to show signs of pathological gaming than any other age group (Griffiths et al. 2004; Griffiths and Wood 2000; Ha et al. 2007). Male adolescents in particular are more likely to play games excessively and are more prone to pathological gaming than adolescent girls are (Chiu et al. 2004; Gentile 2009; Grüsser et al. 2005; Ko et al. 2005). Because of its relatively high prevalence among adolescents, this age group is considered particularly vulnerable to any negative effects that pathological gaming has on players.

If adolescents show signs of pathological involvement with computer or video games, there is an expected increase in the frequency and duration of gaming sessions. Although numerous studies have shown strong correlations between excessive gaming habits and pathological involvement (e.g., Charlton and Danforth 2007; Gentile 2009), to date, no study has examined whether pathological gaming causes gaming binges to exacerbate over time. Therefore, one aim of the current study was to longitudinally examine whether pathological gaming among adolescents predicted an increase in the frequency and duration of gaming sessions. The prolonged inability to control excessive gaming habits coupled with the willingness to sacrifice progressively more in order to continue playing is likely to cause disruptions in the lives of players due to displacement of other important activities, such as educational pursuits or interpersonal contacts (Chiu et al. 2004; Griffiths and Davies 2005).

The occurrence of social and emotional problems is considered a crucial feature in distinguishing addictions from excessive habits (LaRose et al. 2003). Therefore, studies that have applied survey scales to measure pathological gaming have generally included items concerning various problems and conflicts arising from gaming habits (e.g., Charlton and Danforth 2007; Salguero and Moran 2002). This does not mean that all sorts of problematic behavior or negative emotional states are inherently associated with this type of pathological behavior. For instance, lower psychosocial well-being is generally regarded as an antecedent of pathological involvement with (online) games (Lo et al. 2005; Seay and Kraut, 2007), whereas aggressive behavior is generally considered a consequence of pathological gaming (Caplan et al. 2009; Grüsser et al. 2007; Kim et al. 2008). For adolescent gamers and their families, this increase in aggressive outbursts is arguably the most problematic consequence of pathological gaming. Therefore, theoretical explanations of *how* pathological gaming may cause aggressive behavior warrant further examination.

One possible explanation is grounded in the fact that interpersonal aggression can be a consequence of all sorts of addictive behaviors, such as substance dependence (Giancola et al. 1996), alcohol dependence (Pihl and Peterson 1995), and pathological gambling (Parke and Griffiths 2005). There is mounting evidence that this aggression may be caused by craving and withdrawal symptoms following from abstinence after prolonged use (Hoaken and Stewart 2003). In general, withdrawal symptoms cause deficiencies in self-control that are conducive to all sorts of addictive behaviors and may induce relapse after treatment (Baumeister 2003). Among adolescents, deficits in self-control, lack of reflection and/or insensitivity to consequences can lead to unprovoked and disproportionate acts of physical aggression due to decreased functioning of behavioral inhibition (Atkins and Stoff 1993). Similarly, studies have shown that when parents attempt to restrict their children's pathological use of games, these attempts are often met with hostility and aggression (Young 2009). Therefore, aggressive behavior in adolescent players may be partly caused by symptoms inherent to pathological gaming, such as craving for addiction-related stimuli (i.e., games) and withdrawal symptoms when they are forced not to play.

Another explanation why pathological gaming may cause an increase in aggressive behavior concerns the aggression-inducing long-term effects of pathological involvement with *violent* games. Several longitudinal survey studies have indicated that time spent on violent games specifically, and not just any games, causes an increase in aggressive behavior (Anderson et al. 2008; Gentile and Gentile 2008; Möller and Krahé 2009). According to the *General Aggression Model*, use of violent video games can reinforce aggressive scripts, perceptual schemata, aggressive attitudes, and aggression desensitization (e.g., Anderson and Bushman 2002). By constantly rewarding players for violent actions, automated aggressive knowledge structures and emotional desensitization to violent stimuli are learned (Carnagey and Anderson 2005). For instance, when playing a violent game, such as a *first person shooter*, relentlessly shooting and killing opponents is not only rewarded, it is in fact necessary for a player's virtual survival. The more these aggressive actions are rehearsed, the greater their impact on hostile emotion and aggressive thinking (Carnagey and Anderson 2005). Thus, if adolescents show pathological involvement with *violent* games specifically, they may start displaying more aggressive behavior because their excessive involvement with these games has taught them that aggressive responses are an acceptable way to resolve conflicts (e.g., Möller and Krahé 2009).

Although previous studies generally assumed that pathological gaming has an effect on aggressive behavior, and not vice versa (e.g., Caplan et al. 2009; Grüsser et al. 2007; Kim et al. 2008), the cross-sectional nature of these studies does not allow for rigorous testing of such causal assumptions. Furthermore, because these previous studies have not taken into account whether players were pathologically involved with violent or non-violent games, we do not know whether aggressive behavior may be caused, or aggravated by, the violent content of games. Considering the effect of time spent playing violent games on physical aggression that was found in previous longitudinal studies (e.g., Anderson et al. 2008; Gentile and Gentile 2008; Möller and Krahé 2009), we assumed that both pathological and non-pathological involvement with violent games would increase physical aggression among adolescent gamers.

Despite the fact that previous studies have consistently shown that girls are much less likely to play violent games than boys (e.g., Gentile et al. 2004; Möller and Krahé 2009), these studies also showed that *if* girls played violent games, the effects on aggressive behavior were not different from the effects on boys. Because boys are much more likely to play violent games, we expect that boys are also more likely to show pathological involvement with violent games, which makes them more prone to aggression-inducing effects of violent content. Therefore, our final aim was to examine whether the effect of pathological gaming on physical aggression was different between adolescent girls and boys.

The Current Study

This study aims to expand our understanding of adolescents' excessive and pathological involvement with computer or video games and how this behavior is related to physical aggression. Specifically, the current longitudinal study had four main aims. Our first aim was to examine whether pathological gaming among adolescents predicted an increase in the frequency and duration of gaming sessions. Our second aim was to determine if pathological gaming causes an increase in physical aggression. Our third aim was to examine whether the effect of pathological gaming on physical aggression is caused, or aggravated by, violent content of games. Our final aim was to examine whether the possible effects of pathological gaming on physical aggression were different between adolescent girls and boys. For this purpose, we conducted a two-wave panel study among 540 game-playing adolescents from the Netherlands (30% girls).

Method

Sample

In December 2008, 1,024 adolescents from four schools of secondary education in both urban and suburban districts in the Netherlands participated in the first wave of a two-wave longitudinal survey study (51% boys). Students were from various socio-economic and cultural backgrounds, with ages ranging between 11 and 17 years, (mean age = 13.9, SD = 1.4). Six months later, in June 2009, we fielded the second wave among 941 adolescents (mean age 14.3, SD = 1.4). In total, 851 respondents (90% from wave 2) were matched between waves (i.e., corresponding names or student numbers, see procedure below). When respondents indicated that they had not played a computer or video game in the past month, they were exempt from filling in any game-related questions. In the first wave, 76% ($N = 781$) of the respondents played games (37% girls and 63% boys). In the second wave, 68% ($N = 639$) played games (33% girls and 67% boys). Because the analysis technique we used (see data analysis below) does not accept missing cases, we could only include respondents who played games in both waves ($N = 547$). Respondents with more than two missing values on a variable were eliminated from further analysis ($N = 7$). For respondents with one or two missing values, we replaced the missing value by that respondent's mean score on that specific variable. Out of our initial 851 matched respondents (51% boys), 540 game-playing respondents (70% boys) were included in our analyses.

Procedure

In both waves, a paper-and-pencil survey was distributed during school hours after acquiring consent from the schools, teachers and respondents' parents (i.e., parents were informed about the study and could reply if they refused to have their child participate). Consent rates for participation were 100%. In order to match responses from the two waves, respondents were required to fill in either their name or their personal student number. Respondents were assured that their answers would be analyzed only by the principal investigators, and not shown to their teachers or parents. Most participants completed the survey within 20 min and received a small present for their participation.

Measures

Pathological Gaming

To measure respondents' level of pathological gaming, we used a seven-item game addiction scale developed by Lemmens et al. (2009), which is based on the DSM IV-criteria for pathological gambling previously adapted by Griffiths (2005). This scale included one item for each of the seven underlying criteria of pathological gaming: (1) *Salience*: "Did you spend all day thinking about a game?" (2) *Tolerance*: "Did you start spending increasing amounts of time on games?" (3) *Mood modification*: "Have you played games to forget about real life?" (4) *Relapse*: "Have others unsuccessfully tried to reduce your game use?" (5) *Withdrawal*: "Did you feel bad when you were unable to play?" (6) *Conflict*: "Did you have fights with others (e.g., family, friends) over your time spent on games?" (7) *Problems*: "Have you neglected other important activities (e.g., school or work) to play games?" Every item was preceded by the statement: "During the last 6 months, how often…" Players rated all items on a 5-point scale: 1 (*never*), 2 (*rarely*), 3 (*sometimes*), 4 (*often*), 5 (*very often*). Exploratory factor analysis (EFA) indicated that the game addiction scale was unidimensional in both waves, explaining 43% of the variance in wave 1, and 48% in wave 2. The seven-item scale had Cronbach's alphas of .77 ($M = 1.82$, SD = .64) in the first wave, and .81 ($M = 1.68$, SD = .62) in the second wave.

Because it is increasingly believed that mental and behavioral disorders can best be understood as scores on a continuum (e.g., Satcher 2000), we conceptualized pathological gaming as a continuum, instead of using an arbitrary cut-off point to determine if someone is addicted or not. Therefore, contrary to earlier studies (e.g., Charlton and Danforth 2007; Gentile 2009), we performed no dichotomous comparisons (i.e., game addicts vs. non-addicts), but used the individual mean score on the seven-item game addiction scale as an indicator of pathological gaming severity (means ranged from 1 through 4.43 across waves). Respondents' mean scores were not distributed normally, as indicated by the Shapiro–Wilk test. In both waves, mean scores on the game addiction scale were positively skewed. Specifically, 25% ($N = 138$) in wave 1, and 38% ($N = 208$) in wave 2, had a mean score below 1.3, thereby indicating that a large group of adolescent gamers generally never experienced signs of pathological gaming. Conversely, 6% ($N = 34$) in wave 1, and 4% ($N = 21$) in wave 2, had a mean score of 3 or higher on the game addiction scale, which makes it reasonable to assume that a small group of gamers experienced most signs of pathological gaming at least sometimes during the past 6 months.

Time Spent on Games

We asked three sets of questions regarding respondents' time spent playing games on different platforms (PCs, consoles, or handheld gaming devices). First we asked "How many days a week do you play games on a console/pc/handheld". Followed by "On an average day that you play games on a pc/console/handheld, how much time do you spend playing?" The weekly time spent on computer or video games was measured by multiplying the days per week by the number of hours per day spent on these activities. Adolescents generally spent more time playing on a PC ($M = 5.7$, SD = 7.0) than on game consoles ($M = 4.2$, SD = 5.4) or handheld gaming devices ($M = 1.4$, SD = 3.0). Overall time spent on games was calculated by combining the weekly time spent on PCs, consoles, and handheld gaming devices. Weekly time spent on games ranged from 15 min through 77 h per week, with an average of 11.3 h per week (SD = 10.1) across waves. A small group of respondents (4%, $N = 22$) indicated playing computer or video games every day for at least 5 h or more across waves.

Violent Game Play

Following weighted measures of violent video game play (e.g., Gentile and Gentile 2008; Möller and Krahé 2009), we created a weighted score to determine the relative amount of time spent on violent games. Respondents were asked "Which games have you played the most during the last 6 months?" Respondents could report up to three titles, and indicate whether each game was primarily played online or offline. In wave 1, more than 98% of respondents (97% in wave 2) mentioned at least one game title, 83% mentioned two game titles (84% in wave 2), and 54% named three titles (57% in wave 2). All game titles were analyzed and coded for violent content using the Pan-European Game Information (PEGI) online database. Similar to the Entertainment Software Rating Board in the US, PEGI provides detailed recommendations regarding the age suitability of game content in the form of age labels and content descriptors on game packages for over 10.000 computer and video games in 30 European countries (PEGI 2010).

In the current study, games were considered violent when PEGI had labeled them with a "violence" content descriptor, indicating that the game contains depictions of violence, and an age rating of 12, 16 or 18. Games with a violent descriptor and an age rating lower than 12 (e.g., *Bomberman, Ratchet & Clank*) were considered fantasy violence and not coded as violent games. In total, approximately 850 unique titles were mentioned, resulting from 2,524 games being played across waves. 16% of these games consisted of so-called "casual games" (81% online-only) not rated by PEGI because these games are not available through retail. Although some of these casual games may contain violence, they were not coded as violent games. Another 2% were non-descriptive platform names (e.g., *DS, Wii*) also coded as non-violent. In total, more than 2,000 games, totaling approximately 650 unique titles, were examined for violent content and age classification using the PEGI database. Out of the 2,524 games mentioned by participants across waves, 52% ($N = 1{,}301$) was coded as non-violent either because they had a PEGI age rating of 12 or lower without a violence descriptor (33%), because they were either casual games or online-only games, and therefore not rated in the PEGI database (16%), or because they were non-descriptive platform names (2%). In total, 1,223 games (48%) were coded as violent games, either because they had a PEGI age rating of 12 with a violence descriptor (16%), a PEGI age rating of 16 (17%), or because they had a PEGI age rating of 18 (15%). All games with an age rating of 16 or 18 had a PEGI violence descriptor.

The number of violent games reported by each respondent (range 0–3) was divided by the total number of games reported (range 0–3), thereby creating a weighted score of the relative number of violent games played (0, .33, .50, .67, or 1). 40% of respondents had a relative score of 0 ($N = 214$ in wave 1, $N = 219$ in wave 2), indicating that they generally did not play violent games. In contrast, 23% of respondents had a relative score of 1 ($N = 125$ in wave 1, $N = 127$ in wave 2) indicating that they generally only played violent games. In order to create a weighted score of time spent playing violent games, we multiplied the relative amount of violent games by respondents' weekly time spent on games, thereby creating a weighted measure of time spent on violent games for wave 1 ($M = 7.03$, SD = 9.98) and wave 2 ($M = 5.80$, SD = 9.83).

Physical Aggression

Aggression has been defined as physical or nonphysical behavior directed toward harming or injuring another living being who is motivated to avoid such treatment (Baron and Richardson 1994). Since violent games focus almost exclusively on physical acts of violence, effects are expected to show up primarily on physical aggression as an outcome measure. Therefore, in line with previous studies on aggression (e.g., Huesmann and Taylor 2006) we focused on self-reported forms of physical aggression that pose a significant risk of injury to victims. Aggressive behavior was measured using seven items from the Physical Aggression Subscale from Buss and Perry's (1992) Aggression Questionnaire. All seven items measured acts of physical aggression towards others (e.g., fighting, punching). Respondents were asked to reflect on the past 6 months when responding to items, such as: "There are people that pushed me so far that we came to blows" and "Once in a while I can't control the urge to strike another person." Response categories ranged from 1 *(totally disagree)* to 5 *(totally agree)*. EFA indicated that the scale was unidimensional, explaining 63% of the variance in wave 1 and 65% in wave 2. Cronbach's alpha for this scale was .89 in the first wave ($M = 2.11$, SD = .95) and .91 in the second wave ($M = 2.10$, SD = .96). The scale items were averaged to create the measure for physical aggression.

Data Analysis

We tested for causal-correlational relations using autoregressive cross-lagged panel models in structural equation modeling (Amos 7.0). These autoregressive effect models eliminate a considerable proportion of potentially confounding variance and increase the validity of the influence of specific predictors at time 1 on outcomes at time 2 (Schlüter et al. 2006). For the latent constructs aggression and pathological gaming, item parcels served as indicators. Item parcels generally lead to more parsimonious models, reduce the chances for double loadings to occur, diminish the impact of the various sources of sampling error, and are less likely than individual items to violate the assumption of normal distribution (e.g., Little et al. 2002). The items from each construct were distributed over two parcels using the factorial algorithm (see Rogers and Schmitt 2004, for a description of this procedure).

Results

Descriptive Results

Games Played

Across waves, the most popular games were *Call of Duty* (*Modern Warfare* and *World at War*, $N = 237$, 12% of games), *Grand Theft Auto* (*GTA III, San Andreas*, and *GTA IV*, $N = 203$, 10% of games), and *FIFA* (*FIFA 2008* and *FIFA 2009*, $N = 194$, 10% of games). The most popular games overall were identical to the most popular games among male gamers, and most of these were violent. The most popular games among female gamers ($N = 159$) were non-violent games, such as online casual games (e.g., *GoSupermodel, Bubble Trouble*, $N = 181$, 31% of games mentioned by girls), and *The Sims* (*The Sims 1*, *2,* and *3,* $N = 77$, 13% of games mentioned by girls). Approximately 58% of all games were predominantly played online. Respondents' age was not related to the PEGI age ratings of their favorite games, and 42% of respondents reported playing at least one game that was over their age limit.

Correlations Within and Between Waves

Zero-order correlations for all relevant variables are displayed in Table 1. Age of respondents ($M = 14.1$, SD = 1.34) did not show any significant correlation with the variables and was therefore not reported in the table. As the first column of Table 1 shows, female gamers showed less physical aggression, spent less time on games, played less violent games, and showed lower levels of pathological gaming than male adolescent gamers did. Time spent on games, violent game play, and pathological gaming were all correlated with aggressive behavior both within and between waves. Pathological gaming was also correlated between waves ($r = .61$, $p < .001$).

Cross-Lagged Effect of Pathological Gaming on Gaming Habits

The correlations from Table 1 indicated a strong correlation between pathological gaming and the frequency and duration of gaming sessions ($r = .51$ in wave 1, and $r = .45$ in wave 2, $ps < .001$). Our first aim was to examine whether higher levels of pathological gaming in wave 1 predicted an increase in the frequency and duration of gaming sessions in wave 2. For this purpose we tested an autoregressive structural equation model (Cole and Maxwell 2003; Schlüter et al. 2006) as displayed in Fig. 1. The latent construct pathological gaming was estimated from two item-parcels not shown in the figure. Fit indices

Table 1 Correlations within and between waves 1 and 2 ($N = 540$)

	Gender	Physical aggression		Time spent on games		Time spent on violent games	
		W1	W2	W1	W2	W1	W2
Physical aggression							
W1	−.22	1					
W2	−.34	.60	1				
Time spent on games							
W1	−.33	.24	.21	1			
W2	−.32	.19	.19	.58	1		
Time spent on violent games							
W1	−.40	.21	.23	.77	.54	1	
W2	−.33	.19	.19	.48	.88	.61	1
Pathological gaming							
W1	−.24	.33	.29	.51	.41	.48	.35
W2	−.23	.20	.30	.35	.45	.34	.36

Note: Gender is coded; boys 0, girls 1

All correlations are significant at $p < .001$

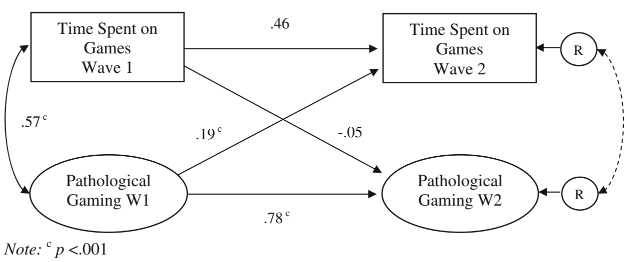

Fig. 1 Autoregressive model with standardized regression weights and covariances of pathological gaming and time spent on games between waves 1 and 2. $^{c}p < .001$

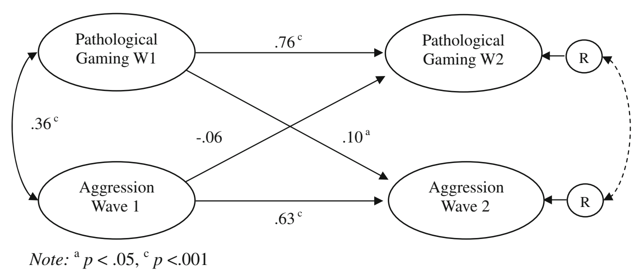

Fig. 2 Autoregressive model with standardized regression weights and covariances of pathological gaming and aggression between waves 1 and 2. $^{a}p < .05$, $^{c}p < .001$

for this model were acceptable, χ^2 (10, $N = 540$) = 32.9, $p < .001$, CFI = .98, RMSEA = .065 (90% CI: .041; .091). As this figure shows, pathological gaming in wave 1 predicted an increase in time spent on games in wave 2 ($\beta = .19$, $B = 3.48$, SE = .904, $p < .001$). Time spent on games in wave 1 did not predict pathological gaming in wave 2 ($\beta = -.05$, $B = -.01$, SE = .002, $p = .33$). These findings indicated that higher levels of pathological gaming predicted a significant increase in the frequency and duration of gaming sessions 6 months later.

Cross-Lagged Effect of Pathological Gaming on Physical Aggression

To investigate the causal relationship between pathological gaming and physical aggression, we tested an autoregressive structural equation model as displayed in Fig. 2. The ovals represent the latent constructs pathological gaming and physical aggression, which were estimated from two item-parcels not shown in the figure. Fit indices for this model were acceptable, χ^2 (14, $N = 540$) = 36.2, $p = .001$, CFI = .99, RMSEA = .065 (90% CI: .039; .091). As Fig. 2 shows, pathological gaming in wave 1 predicted an increase in aggressive behavior in wave 2 ($\beta = .10$, $B = .16$, SE = .069, $p < .05$). The causal-correlational effect of aggression in wave 1 on pathological gaming in wave 2 was not significant ($\beta = -.06$, $B = -.04$, SE = .028, $p = .22$). Because our initial analyses indicated that the distribution of pathological gaming scores was skewed, we applied a bootstrap procedure to our models to improve the statistical significance of our findings. The bias-corrected 95% confidence interval for the regression coefficients indicated that the effect of pathological gaming on physical aggression remained significant ($B = .19$, SE = .098, $p = .03$). These results show that higher levels of pathological gaming caused an increase in physical aggression 6 months later, but not vice versa.

In order to examine whether pathological involvement with violent or non-violent games influenced the effect of pathological gaming on physical aggression, we first dichotomized the weighted score of the relative number of violent games played in wave 1 (0, .33 = preference non-violent games; .67, 1 = preference violent games). Relative violent scores of .5 indicated that these respondents had reported two favorite games, one violent, and one non-violent. Because these specific scores did not indicate a preference for either violent or non-violent games, respondents with a score of .5 were omitted from this analysis ($N = 38$). Next, we performed multi-group analysis (Jaccard and Wan 1996) to the model presented in Fig. 2, in order to test whether observed differences in the structural weights for the path between pathological gaming wave 1 and physical aggression wave 2 were statistically significant between players of mostly violent games ($N = 215$) and players of mostly non-violent games ($N = 287$).

We estimated a model, in which we did not pose any cross-group constraints, i.e., we allowed the causal path between pathological gaming wave 1 and physical aggression wave 2 to vary between violent gamers and non-violent gamers. In a subsequent model, we constrained this path to be equal across gamers. We tested whether the fit of the constrained model differed from the fit of the unconstrained model. A significant change in the model fit would indicate that the constrained path differed between violent and non-violent gamers, thereby indicating moderation. Multi-group analyses showed no significant chi-square change ($\Delta\chi^2$ ($N = 502$) = .38, $p = .54$). These findings indicated that the effect of pathological gaming on physical aggression was not significantly affected by the violent or non-violent content of games.

Cross-Lagged Effect of Violent Game Play on Physical Aggression

In order to examine whether the effect of playing violent games on aggressive behavior that was found in previous studies also held for our sample of adolescents, we tested two autoregressive models. We examined the effects of time spent on games and time spent on violent games, as displayed in Fig. 3. The rectangular boxes marked *Game Play* represent one of the two manifest constructs: time spent on games, or time spent on violent games.

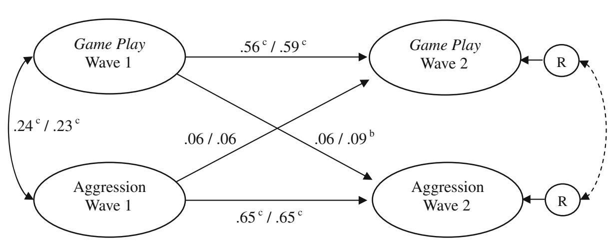

Fig. 3 Autoregressive model with standardized regression weights and covariances of game play and physical aggression between waves 1 and 2. Coefficients before the slash (/) are for time spent on games, coefficients after the slash are for time spent on violent games. [b]$p < .01$, [c]$p < .001$

Coefficients for these constructs are separated by a slash. Both model fit indices were acceptable; time spent on games: χ^2 (5, $N = 540$) = 16.7, $p = .001$, CFI = .99, RMSEA = .066, 90% CI: .03–1.0, and time spent on violent games: χ^2 (5, $N = 540$) = 15.8, $p = .001$, CFI = .99, RMSEA =.063, 90% CI: .03–1.0.

As Fig. 3 shows, the causal-correlational effect of time spent on games in wave 1 on physical aggression in wave 2 ($\beta = .06$, $B = .01$, SE = .003, $p = .09$) was not significant. The causal-correlational effect of aggression in wave 1 on time spent on games in wave 2 ($\beta = .06$, $B = .75$, SE = .462, $p = .10$) was also not significant. However, time spent on violent games in wave 1 showed a significant causal-correlational effect on physical aggression in wave 2 ($\beta = .09$, $B = .01$, SE = .003, $p < .01$), but physical aggression in wave 1 did not have a causal-correlational effect on violent game play in wave 2 ($\beta = .06$, $B = .63$, SE = .411, $p = .12$). These results indicate that time spent on games in general did not increase physical aggression, but playing violent games did cause an increase in self-reported physically aggressive behavior.

Gender Moderator Analyses

The zero-order correlations from Table 1 indicated that gender influenced all game play variables and physical aggression. Across waves, male gamers spent an average of 13.6 h (SD = 10.7) per week on games, which is much more than female gamers, who spent an average of 5.5 h (SD = 5.6) per week on games, t (536) = 9.06, $p < .001$. Similarly, levels of pathological gaming were lower for girls ($M = 1.52$, SD = .59) than for boys ($M = 1.85$, SD = .47), t (536) = 6.18, $p < .001$. Regarding use of violent games, we found that only 7% of the favorite games reported by girls were coded violent, whereas 57% of the games reported by boys were coded violent games. Similarly, across waves, time spent on violent games was much lower for girls ($M = .78$, SD = 3.6) than for boys ($M = 8.75$, SD = 9.33), t (536) = 10.40, $p < .001$. Gender also influenced self-reported physically aggressive behavior across waves, with boys ($M = 2.14$, SD = .76) showing more physical aggression than girls ($M = 1.61$, SD = .62), t (536) = 7.62, $p < .001$.

Because of these gender differences, our next aim was to examine whether gender moderated the effects on physical aggression found in our models (i.e., the effects of pathological gaming on physical aggression, and the effect of violent game play on physical aggression). To do so, we performed multi-group analysis to test whether observed differences in the structural weights are statistically significant between genders. We examined whether gender moderated the effect of violent game play on physical aggression by constraining the path between violent game play in wave 1 and aggression in wave 2 (Fig. 3). Multi-group analyses indicated no significant chi-square change ($\Delta\chi^2$ ($N = 540$) = 3.01, $p = .08$). Similar to previous studies, our findings showed that although girls were much less likely to play violent games, the effect of playing violent games on physical aggression was not significantly different between girls and boys.

Because girls were generally not likely to play violent games, we expected that any pathological involvement among girls would likely be with non-violent games. Thus, respondents' gender could moderate the effect of pathological gaming on physical aggression. We examined whether gender moderated the effect of pathological gaming on physical aggression by constraining the path between pathological gaming in wave 1 and physical aggression in wave 2 (Fig. 2). Multi-group analyses indicated a significant chi-square change ($\Delta\chi^2$ ($N = 540$) = 15.79, $p <$ .001). Among male gamers, higher levels of pathological gaming predicted an increase in physical aggression 6 months later ($\beta = .13$, $B = .20$, SE = .084, $p = .02$). However, among female gamers, higher levels of pathological gaming predicted an unexpected decrease in physical aggression 6 months later ($\beta = -.24$, $B = -.35$, SE = .115, $p < .01$).

Discussion

Based on the definition for pathological gambling from the DSM (APA 2000), pathological gaming is defined as the persistent and recurrent inability to control excessive gaming habits despite associated social and/or emotional problems (Lemmens et al. 2009). Several cross-sectional studies have shown that a small group of predominantly male adolescent gamers display numerous signs of pathological gaming while spending excessive amounts of time on games (e.g., Charlton and Danforth 2007; Gentile 2009). Although many studies have implicitly assumed that pathological involvement leads to increasingly excessive gaming binges, the cross-sectional nature of these studies cannot decisively demonstrate whether pathological gaming is indeed progressive, causing excessive gaming habits to exacerbate over time. Similarly, cross-sectional studies that have shown a relationship between pathological gaming and aggressive behavior have generally assumed that pathological involvement causes an increase in aggressive behavior (Caplan et al. 2009; Grüsser et al. 2007; Kim et al. 2008). However, because no longitudinal studies on the relation between pathological gaming and aggressive behavior exist, the effect of pathological gaming on aggressive behavior has never been decisively demonstrated. Furthermore, since previous studies have not taken the content of games into account, we do not know whether aggressive behavior is caused, or possibly aggravated by, pathological involvement with violent games. The present study is the first to address these issues by longitudinally examining the causal relations between pathological gaming, excessive gaming, and physical aggression among 540 adolescent gamers.

Our study yielded three main findings. First, we found that higher levels of pathological gaming predicted a substantial increase in the frequency and duration of gaming sessions 6 months later. This indicates that pathological gaming may be considered progressive, and if this behavior is not controlled or reduced, excessive gaming habits could exacerbate over time, which will likely lead to problems by displacing other important activities (e.g., Griffiths and Davies 2005). Conversely, spending time on games did not predict an increase in pathological involvement, which could indicate that playing computer and video games is not inherently addictive. Second, we found that higher levels of pathological gaming predicted an increase in self-reported physical aggression 6 months later, regardless of whether players were involved with violent or non-violent games. However, this effect was found only for adolescent boys. Adolescent boys predominantly played violent games, with the greater part of their favorite games showing realistic violence considered inappropriate for any adolescent under 18. Therefore, pathological involvement among boys was likely to be with violent games, which may have aggravated the effect on physical aggression. Third, in agreement with previous longitudinal studies, we found that time spent playing violent games specifically, and not just time spent playing games, caused an increase in aggressive behavior (Anderson et al. 2008; Gentile and Gentile 2008; Möller and Krahé 2009). This shows that the violent content of games was predictive of future physical aggression. Similar to these studies, we found no support for the reciprocal relation reported by Slater et al. (2003), meaning that individual levels of physical aggression did not predict future time spent on violent games. In sum, these findings underline the negative effects of pathological gaming on adolescent gamers, especially if it involves violent games.

In general, pathological involvement with computer or video games seems mostly restricted to adolescent boys. In line with previous findings, the vast majority of adolescent girls showed neither signs of excessive nor pathological gaming (e.g., Griffiths et al. 2004). Furthermore, only a very small minority of female gamers played violent games, and even if adolescent girls played violent games, they spent much less time on them than boys did. This gender difference in violent game play may have attributed to the gender differences in the effect of pathological gaming on physical aggression. Contrary to boys, pathological gaming among adolescent girls actually predicted a decrease in self-reported physical aggression. Similar to the effects of playing violent games on aggression (e.g., Möller and Krahé 2009) previous research has also shown a parallel effect: playing social games tends to increase pro-social thoughts and behavior (Gentile et al. 2009). Therefore, girls' pathological involvement in distinctively non-violent, arguably social games (e.g., *The Sims*), could explain the reduction in physical aggression 6 months later.

For male adolescent gamers, pathological involvement with predominantly violent games may explain some of the effect on physical aggression, but our moderation analyses indicated that pathological gaming predicted an increase in physical aggression regardless of violent content. As we previously concluded, high levels of pathological involvement lead to increasingly excessive amounts of time spent on games, which likely leads to displacement of other important activities such as school or homework. These progressive gaming habits may eventually cause problems at school and conflicts with their parents. When attempts are made to stop this excessive behavior, withdrawal symptoms following from abstinence after prolonged use can lead to irritability and aggression (e.g., Young 2009). This could cause adolescents to behave hostile and aggressive in situations where they cannot play, for instance at school, or at home when their parents attempt to restrict them from playing. In turn, this could provide an alternate explanation for the increase in physically aggressive behavior following pathological involvement with games, regardless of the violent content.

The practical implications of these findings may be somewhat disconcerting because they could lead parents to assume that aggressive behavior can be avoided as long as they do not interfere with pathological gaming habits. However, not interfering in order to avoid aggressive reactions and conflicts will exacerbate excessive gaming habits and likely increase associated problems. Furthermore, all addictions and pathological behavior identified in adults commonly start in adolescence or young adulthood (e.g., Wagner and Anthony 2002). Thus, if signs of pathological gaming among adolescents are not handled properly, this progressive condition may cause serious problems as these gamers progress into young adulthood, when they are expected to become independent from their parents, find employment or attend higher education.

The current study expanded on research from previous studies by using a more objective rating system to determine whether a game could be considered violent or non-violent, rather than subjective assessments of violent content (e.g., Anderson et al. 2008; Möller and Krahé 2009). However, this dichotomization of violent or non-violent games may have come at the cost of some variance, thereby possibly limiting our effect sizes. Other limitations of our study include the reliance on self-report measures for physical aggression and pathological gaming, both of which are much more common among adolescent boys. Our focus on physical aggression also limits our understanding of the development of other types of aggressive behavior that were not analyzed in the current study, such as social and relational aggression, which may be more prominent among adolescent girls. Nevertheless, our two-wave panel study of Dutch adolescents has broadened the degree of reasonable generalization for the effects of violent games on physically aggressive behavior. Our study has also provided evidence that pathological gaming causes an increase in physical aggression among adolescent boys. The finding that pathological gaming only affects physical aggression among boys does not diminish its importance because adolescent boys are generally the most devoted group of violent game players and most susceptible to pathological involvement.

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