



Who is Most at Risk for Developing Physical Aggression After Playing Violent Video Games? An Individual Differences Perspective From Early Adolescence to Emerging Adulthood

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Abstract

Many theories of development suggest that playing violent video games would not impact all adolescents the same way, yet empirical research is sparse. To date there have been no within-subjects analyses that examine which adolescents are most at risk for developing aggression after playing violent video games and under what context, and no longitudinal studies encompassing multiple developmental stages (i.e., early adolescence to emerging adulthood) that examine the long-term effects of playing violent video games. To address this gap, the current study used a longitudinal design (spanning 8 years and encompassing multiple developmental periods) with a sample of U.S. adolescents who completed questionnaires on aggression, video gaming, and multiple risk and protective factors for aggression. Participants included 488 adolescents (M age = 13.82, SD = 1.03 at the initial wave, 51% female, with 65% being White, 12% Black, 19% multiethnic, and 4% other). Mixture regression was utilized to model physical aggression over time and to examine how playing violent video games might be related to aggression on an individual level. There were four classes: “Multi-risk”, “High Gaming, High Aggression” (both of which had high levels of aggression over time), “Moderate Risk”, and “Low Risk, High Privilege” (both of which had lower levels of aggression over time). Individuals were most aggressive with multiple risk factors or higher levels of violent game play and playing violent video games likely increased aggression more in individuals with other gaming problems and in males with low self-regulation. The results are discussed using a balanced perspective and recognize that violent video games do not affect all adolescents the same way. This research has direct implications for designing interventions around reducing aggressive behavior among adolescents.

Keywords Gaming · Violence · Aggression · Adolescence · Differential susceptibility

Introduction

Video games have existed since the 1970s; however, there is still heated debate on the degree to which violent games impact aggressive behavior, particularly among adolescents (e.g., Bushman et al., 2022; Ferguson and Kilburn, 2010; Ybarra et al., 2022). Aggressive behavior is complex. It is

logical, then, that the long-term behavioral effects of playing violent video games are likely equally nuanced and intricate and involve a variety of individual, family, peer, and societal factors. To date, the video game violence literature has primarily focused on between-subjects comparisons, which does not allow for an examination of individual risk in the context of other factors. This has resulted in limited capacity to identify who might be more at risk for developing aggressive behavior over time as a result of playing violent video games and has likely diminished the effectiveness of interventions aimed at

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reducing aggression during adolescence. The current article reports data from an 8-year longitudinal study across early adolescence to emerging adulthood, with a focus on identifying individual risk factors for video-game-related aggression. The effects of video game violence on aggression are explored by using a person-centered statistical methodology to discover for *whom* and *under what circumstances* playing violent video games are related to changes in aggressive behavior, and for whom and under what circumstances it is not.

Aggression During Adolescence

Generally speaking, physical aggression tends to peak in the toddler years and then decline across the lifespan, although children who are initially more aggressive tend to remain more aggressive than their peers (Warburton and Anderson, 2018). While this pattern is typical (Huesmann et al., 2009), there is some heterogeneity in aggressiveness pathways over time. From the early school years through adolescence, physical aggression tends to slowly decline or stay stable for most children (Girard et al., 2019). However, during adolescence, different pathways have been noted. Most teens still follow a pattern of stable or declining aggression, but some demonstrate noticeable increases or decreases in their aggressiveness trajectory (Piquero et al., 2012). Teens whose aggressiveness trajectory increases often have risk factors related to family life, disadvantage, or personality characteristics (Warburton and Anderson, 2018). Indeed, extensive changes in the developing adolescent brain increase the chances of behavioral problems arising (Giedd, 2015). Teenagers may struggle to manage their impulses and emotions, may be vulnerable to influence, may take risks, may develop mental health concerns, and may have impaired behavioral control. Of course, there are substantial individual differences, and some adolescents are more vulnerable than others. One factor that has been examined in the context of the development of aggressive behavior is exposure to violent video games during adolescence.

Violent Video Games and Aggressive Behavior

Since the proliferation of video gaming systems across the globe, the majority of the best-selling games have contained violence and aggression (Dill et al., 2005). A handful of content analyses, although outdated, have suggested that the majority of best-selling video games have violence as their major theme and as video games have become more realistic, the violence has become more graphic and realistic as well (Hartmann et al., 2014).

Decades of research (including multiple meta-analyses) have shown a consistent, albeit modest, relationship between exposure to violent video games and increased

aggressive behavior across multiple study types (e.g., Anderson et al., 2010; Greitemeyer and Mügge, 2014; Prescott et al., 2018). Nevertheless, the theoretical and empirical debate surrounding this topic is still contested. Authors in support of the assertion that violent video game play increases aggressive behavior tend to subscribe to the General Aggression Model, which suggests that short-term and long-term exposure to violent video games changes cognitions, affect, and arousal in such a way that players are more likely to respond aggressively in socially ambiguous environments or when provoked (Anderson and Bushman, 2018). Other researchers have pointed out issues related to study design, publication bias and the external validity of laboratory measures of aggression (e.g., Ferguson, 2018), and have argued that the effects of media violence on violent behaviors are trivial or so small that they are not statistically relevant when examined within the larger context of development or other risk factors for violence (Ferguson and Wang, 2019, 2021). The media violence debate is contentious, and on occasion different researchers have drawn different conclusions from the same data sets (e.g., Anderson et al., 2010; Ferguson et al., 2020; Mathur and VanderWeele, 2019). However, controversy is the foundation of empiricism and is an important part of the scientific process.

In general, much research on violent video games and aggressive behavior has one or more of four issues that limit wider interpretation and likely contribute to confusion and the mixed results: (1) it is cross-sectional in nature, (2) it focuses on between-subjects comparisons, (3) the data encompasses only short-term effects, and (4) it lacks covariates with aggression. The current study directly answers these limitations by being longitudinal (encompassing multiple developmental time periods), studying both between and within subjects effects allowing us to examine change in aggressive behavior both between and within individuals, and including multiple other risk and protective factors to examine how individual risk of playing violent video games might be related to aggression over time.

Differential Susceptibility

The differential susceptibility to media effects model (DSMM) theorizes that individuals have varying levels of susceptibility to media effects and that media influences behavior, affect, and emotions at higher levels for some children than for others (Piotrowski and Valkenburg, 2015; Valkenburg and Peter, 2013). Susceptibility is also viewed as a multifaceted construct that includes dispositional (e.g., existing hostility or aggression), developmental (e.g., age of child or developmental maturity), and social (e.g., parental media monitoring or peer culture) susceptibility. This model assumes that people choose media to fulfill certain needs

and that media content interacts with individual person characteristics that may influence behavior (Fikkers and Piotrowski, 2020).

Research has begun to examine vulnerability to media effects through moderation analysis. This type of analysis typically compares group differences without any attention to individual-level characteristics. For example, it may be that individuals who come from chaotic family environments tend to be more vulnerable to violent video games (in terms of playing higher levels of violent video games and developing subsequent aggressive behavior) than individuals who grow up in stable family homes (e.g., Shao and Wang, 2019). However, a myriad of other factors, unrelated to stability, might also influence aggressive behavior. Indeed, video games may have nothing to do with the increase in individual aggressive levels for adolescents living with highly chaotic families. Understanding *individual risk* may inform both prevention and intervention efforts to decrease aggressive behavior across development when media effects are examined at a micro level. This type of research is being conducted on the effects of social media on mental health (Valkenburg et al., 2021), but to the researchers' knowledge, little research has used person-centered approaches to study violent video games—the approach taken in the current study, which utilizes mixture regression (e.g., Dyer et al., 2012).

Mixture regression extends beyond the simple moderation of interaction terms or multiple group analyses. Rather, it identifies “latent class” varying effects independent of whether a specific moderator variable relates to that varying effect. Whereas previous work has only identified the various relationships between video game use and aggression using observed mediators, mixture regression more fully identifies unobserved heterogeneity by specifying a latent variable indicative of heterogeneity and independent of any observed moderators. Predicting the latent class variable which represents this heterogeneity more effectively tests high-order and multiple interactions at both a group and individual level.

Mixture regression also allows a nuanced analysis of an outcome (such as physical aggression) based on the ranges and balances of risk and protective factors (i.e., to take a risk and resilience approach). Such an approach more fully tests theoretical models based on the premise that some contextual factors may increase behavioral likelihood and some may decrease it. For example, all violence, and much aggression, occurs because the context around the perpetrator includes a range of risk factors for aggressive behavior with few protective factors to mitigate them (Warburton and Anderson, 2015, 2018). Risk and resilience approaches emphasize that the causes of behavior are multifactorial, nuanced, and different for each individual. Rather than seeing a single factor as a cause for a

phenomenon, this approach looks at a range of factors and how they interact. Risk and resilience models have been used successfully to better understand media violence (Gentile and Bushman, 2012) and Internet Gaming Disorder (IGD) (Warburton et al., 2022). A context-driven approach such as this provides a distinctive method for understanding the development of aggression in adolescents in a nuanced way.

According to the DSMM, there are many contextual factors that could be examined when thinking about individual level of risk. In the current study, individual and dispositional relationships (gender, race, self-regulation, depression, and physiological reactivity), familial relationships (income, parenting, family chaos, and stress), peer relationships (victimization and relational aggression), and the broader relationship with media (IGD and media monitoring) are examined as potential risk or protective factors of aggressive behavior.

However, it should be noted that mixture regression analyses may lead researchers to conclude that the relationship between the independent and dependent variable is not heterogeneous. Thus, mixture regression does not necessarily find heterogeneity, but rather is designed to identify heterogeneity if it exists.

Individual and dispositional factors

Several individual factors were examined that are known to influence aggressive behavior, beginning with gender where research has consistently shown that adolescent males are more physically aggressive than adolescent females (Nivette et al., 2018). Regulatory abilities were also examined. Previous researchers have shown that poor impulse control (Connor et al., 2019) and emotion regulation (Moore et al., 2019) are related to increased aggressive behavior in adolescence and this may extend to those who play video games (Coyne et al., 2020a). For the purposes of this study, self-regulation skills were examined more broadly to encompass more general regulatory processes. Additionally, developmental research has also suggested that physically aggressive behavior in childhood places adolescents at increased risk for depression and anxiety (Blain-Arcaro and Vaillancourt, 2016). Excessive video game play has also been associated with increased internalizing behaviors, such as depressive symptoms (Coyne et al., 2020a).

Finally, physiological reactivity was assessed as a potential risk factor for aggressive behavior. Differential susceptibility can also have a biologic component; some individuals' physiological systems naturally increase their likelihood of behaving aggressively (Ellis and Boyce, 2011). For example, some studies have suggested that muted physiological reactivity is related to increased relational aggression in female teens, while hyper-reactivity is

related to increased physical aggression (Sijtsema et al., 2011). While more work is needed to understand all of the individual factors that put teens at risk for aggressive behavior, past research supports including gender, regulatory abilities, depression, and physiological reactivity as potential individual factors that may influence the longitudinal relationships between exposure to violent video games and aggressive behavior.

Familial factors

Parenting and family factors such as economic deprivation, high family stress, and problematic parenting have long been studied as potential risk and protective factors of aggressive behavior. Longitudinal research has shown that adolescents from low-income families are at greater risk of aggressive behavior (Côté et al., 2006). Moreover, low-income families, compared to high-income families, are more likely to report allowing their adolescents to have TVs in their bedrooms (Gentile and Walsh, 2002), potentially increasing their access to violent media.

Across developmental periods and in many cultures, high levels of parental control, hostility, and criticism, as well as low levels of parental warmth, have been key parenting predictors of child and adolescent aggression (e.g., Pinquart, 2017). It is plausible that these parental characteristics may also buffer against the negative effects of violent video games. Family disorder and stress are also important familial factors that are related to aggressive behavior, most notably through parenting behaviors. For example, associations between high aggressive behavior and exposure to media violence have been shown to be stronger for adolescents from high conflictual family environments (Fikkers et al., 2013). Adolescents may experience a double-dose effect through direct exposure to aggression via the family environment and through indirect exposure to violent media, increasing their database of and preferential access to aggressive scripts for resolving conflict. Frequent exposure to a conflictual family environment and media violence may lead to increases in aggression through adolescents' cognitive standards about the acceptability of aggression (i.e., normative beliefs) (Huesmann and Guerra, 1997).

Peer factors

Peer factors such as victimization and relational aggression are also important components of the research regarding adolescent aggressive behavior. Peer victimization has been linked to short- and long-term internalizing and externalizing problems, including heightened anxiety and depression and low self-esteem, as well as peer rejection, aggressive behavior, and problematic friendships (e.g., Söderberg and Björkqvist, 2020). A recent meta-analysis of longitudinal

studies assessing bullying perpetration and victimization found strong bidirectional associations between concurrent and prospective aggression and victimization in adolescents (Walters, 2021). More specifically, aggressive adolescents are more likely to be targets of victimization. Being victimized, in turn, increases adolescents' aggressiveness. This pattern has been referred to as the *cycle of violence* (Walters, 2021) and likely enhances an individual's aggressive tendencies, including exposure to violent video games.

Relational aggression (also referred to as indirect aggression or social aggression) is characterized by dissolving, manipulating, or threatening social relationships through social exclusion, gossip, and rumor spreading (Archer and Coyne, 2005). While the majority of adolescents engage in low levels of relational aggression, a small percentage show a high, increasing trajectory between adolescence and emerging adulthood (Coyne et al., 2020b). In addition, multiple studies have shown that relational aggression covaries with physical aggression (e.g., Card et al., 2008). Thus, adolescents' existing levels of relational aggression may serve as a risk factor for ongoing aggressive behavior and exposure to violent video games.

Media factors

Two additional potential media factors were examined that might be important. Increased aggression has been well documented in teenagers with IGD (Marshall et al., 2022). Thus, screen disorders such as IGD are potential risk factors for aggression. Additionally, parental mediation strategies around media, such as active mediation (helping children think critically around media) or restrictive mediation (setting limits and rules around media), might also decrease the impact of violent video games on aggressive behavior (e.g., Collier et al., 2016).

Current Study

Though much research has been conducted on the topic of violent video games and aggression, individual susceptibility has been mostly ignored. The purpose of the current study is to use a person-centered approach to examine who is most at risk for developing aggression between early adolescence and emerging adulthood after playing violent video games. This analysis is somewhat exploratory, but it was hypothesized that individuals with other risk factors for aggressive behavior (e.g., male, low parental warmth, physiologically reactive, low self-regulation) will be most at risk for developing aggressive behavior over time. However, individual trajectories will be explored allowing for much greater nuance than a simple hypothesis can predict. The hope is that this study moves the field beyond the

“good vs. bad” distinction that is so hotly debated in the violent video game area and instead provide a sophisticated analysis that informs both prevention and intervention efforts aimed at reducing aggression due to playing violent video games at the individual level. Hypotheses were pre-registered via the Open Science Foundation Network (study registration: osf.io/f7bvc).

Method

Participants

Participants included 500 adolescents who participated in [Project Masked for Review], which is an ongoing, longitudinal study of inner family life involving families with a child between the ages of 10 and 13 ($N = 500$; 51.6% female). The data from the current article is from Waves 3–10, when video games were first included in data measurement ($N = 488$). Participant children averaged 13.82 ($SD = 1.03$) years of age at the start of the study (Wave 3). Approximately 65% of families were White, 12% were Black, 19% were multiethnic, and 4% were other. There was an 89.75% retention rate between Waves 3 to 10. Attrition analyses revealed that those who dropped out of the study were more likely to be non-white ($p < 0.001$, $\eta^2 = 0.03$), lower income, ($p < 0.001$, $\eta^2 = 0.03$) and come from single-parent families ($p = 0.002$, $\eta^2 = 0.02$).

Procedure

Participant families were selected from a large northwestern city and interviewed during the first 8 months of 2007 for a Wave 1 data sample. Wave 3 (the first year in the current study) took place in 2009. Participants took part in the study once a year each year through Wave 10. Families were primarily recruited using a purchased national telephone survey database (Polk Directories/InfoUSA) and were randomly selected from targeted census tracts that mirrored the socioeconomic and racial stratification of reports of local school districts. Of the 692 eligible families contacted, 423 agreed to participate, resulting in a 61% response rate. The most frequent reasons cited by families for not wanting to participate in the study were lack of time and concerns about privacy. However, the Polk Directory national database was generated using telephone, magazine, and internet subscription reports; as a result, families of lower socioeconomic status were underrepresented. Therefore, to more closely mirror the demographics of the local area, the researchers recruited a limited number of families into the study via other means ($n = 77$, 15%). This consisted of referrals from other families and posting fliers in low

income neighborhoods and in social services offices (e.g., WIC, Housing and Urban Development).

Participants completed electronic questionnaires at each wave. Participants were given \$50 for their time. Dropout analyses revealed that the data were missing at random and can be accessed by contacting the primary author. Missing data was handled using the maximum likelihood method in Mplus, which estimates the most likely outcome in the presence of missing data.

Measures

Physical aggression (Waves 3–10)

Aggressive behavior was assessed using five items taken from Weinberger et al. (1979). Participants rated the degree to which these items described them using a 5-point Likert scale ranging from 1 (*does not describe me*) to 5 (*describes me very well*). These items were: “I use physical force when angry”, “People who get me angry better watch out”, “If someone tries to hurt me, I make sure to get even with them”, “If someone does something to me that I don’t like, I yell at them about it”, “I lose my temper and “let people have it” when I am angry”. Reliability coefficients for the current sample were found to be acceptable at every wave (ranging from $\alpha = 0.83$ to $\alpha = 0.88$).

Video Game Violence (Wave 3)

Participants listed their three favorite video games and rated how frequently they played each game on a scale of 1 (*not frequently*) to 5 (*extremely frequently*). A total of 789 games were mentioned across the 10 waves. Each game was given a violence rating on a 0 (*no violence*) to 5 (*extreme violence*) Likert scale ($N = 511$). Ratings were obtained using scoring from the media content coding website Common Sense Media (2022).

As an example, *Call of Duty*, *Dead Rising*, *Gears of War*, and *Grand Theft Auto* were all rated as 5 s, and *1010*, *American Idol*, *Bejeweled*, and *Boggle* were all rated as 0 s. The study authors requested reliability statistics from the company, but they did not have the formal reliability statistics that are common in this type of research. Thus, reliability analysis were conducted on the ratings and found the ratings to be valid and reliable ($r = 0.80$, $SD = 0.07$). A description of how this analysis was completed is available in Coyne and Stockdale (2021) and can also be found repeated in the supplementary material. A video game violence exposure score was computed by multiplying content ratings by frequency of game play, giving more weight to games that were played more frequently.

Parental Warmth and Hostility (Wave 3)

Parenting behaviors and parenting styles was measured using the Parenting Styles and Dimensions Questionnaire—Short Version (PSDQ; Robinson et al. 2001). We asked adolescents how often their parent(s) exhibited certain behaviors relating to parenting style. Responses ranged from 1 (*never*) to 5 (*always*). Five items assessed warmth (e.g., “My parent is responsive to my feelings and needs”: $\alpha = 0.91$), and four items assessed hostility (e.g., “My parent explodes in anger toward me”: $\alpha = 0.82$).

Bullying Victimization (Wave 3)

Children’s perception of being bullied was assessed using seven items from Moore and Lippman (2005), with respondents reporting how often items occurred (1 = *never* to 4 = *very often*; sample items included, “How often are you bullied by classmates or neighborhood kids?”) Reliability was acceptable ($\alpha = 0.97$).

Media Monitoring (Wave 3)

Parental monitoring of children’s media exposure was examined using items adapted from Nikken and Jansz (2006). Participants responded to seven items, rating how often their parents engaged in specific monitoring behaviors, using a 5-point Likert scale, from 1 (*never*) to 5 (*very often*). Higher scores reflect greater perceived monitoring of children’s media exposure. Sample items included, “Tell you to turn off media when they think it is inappropriate,” and “Try to help you understand what you see in the media,” Reliability was acceptable ($\alpha = 0.92$).

Self-Regulation (Wave 3)

Children’s ability to regulate disruptive behavior was assessed using a modified 5-item measure (Novak and Clayton, 2001). Responses ranged from 1 (*never true*) to 4 (*always true*). Sample items included, “I have a hard time sitting still during important tasks”. Higher scores represent greater ability to regulate negative behavior and to reach goals. Reliability was acceptable ($\alpha = 0.98$).

Depression (Wave 3)

Children’s depression was measured using the 20-item self-report CES-DC (Center for Epidemiological Studies Depression Scale for Children) (Weissman et al., 1980). Participants responded by rating the degree to which they have experienced each item in the past week, with a Likert-type response scale ranging from 1 (*not at all*) to 4 (*a lot*).

Higher scores indicate greater depressive symptoms. Sample items included, “I was bothered by things that usually don’t bother me”. Reliability was acceptable ($\alpha = 0.90$).

Stressful Life Events (Wave 3)

Children’s experience of stressful life events was assessed using seven items from Johnson (1986). Respondents answered how recently events happened by marking 0 (*never happened*), 1 (*happened over a year ago*), or 2 (*happened in the last year*). Sample items included, “Parent going to jail,” “Parent getting in trouble with the law,” and “Frequent arguments between parents.” Scores were summed and higher scores represent more stressor events for a family or an individual, more recent occurrence of stressful life events, or both. Reliability was moderate ($\alpha = 0.64$).

Three other measures were included (internet gaming disorder, relational aggression, and physiological reactivity) that were not assessed during the initial wave but were assessed in Wave 4 or Wave 5. It was anticipated that these measures would be relevant to either aggressive behavior or video game play. These measures also tend to be moderately stable over time (particularly over a single year), so it was expected that there would be little variance between time points for these particular variables (e.g., Coyne et al. 2020a, 2020b; El-Sheikh 2007).

Internet Gaming Disorder Symptoms (Wave 5)

Adolescents completed an 11-item measure assessing IGD symptoms. Survey items were based on the DSM-IV criteria for pathological gambling and adapted to apply to video gaming (Gentile, 2009). Sample items included, “Do you need to spend more and more time and/or money on video games in order to feel the same amount of excitement?” Responses varied between “yes,” “no,” and “sometimes,” and “yes” and “sometimes” were considered evidence of pathological symptomology. The number of video game symptoms was summed (with a range of 0–11 symptoms). Reliability was acceptable ($\alpha = 0.78$).

Relational Aggression (Wave 4)

Participants rated their own use of relational aggression against peers using four items from the Peer and Romantic Relations Inventory—Self Report (PRRI-S; Nelson, 2005). Items were rated on a 5-point Likert-scale, ranging from 1 (*never true*) to 5 (*almost always true*). One sample item from the current study was “When mad at a person, I try to make sure that the person is left out from group activities.” Cronbach’s alpha was acceptable: $\alpha = 0.71$.

Physiological Reactivity—Autonomic Nervous System (Wave 5)

Autonomic Nervous System (ANS) data collection proceeded as follows: After electrodes were placed and after a period of acclimatization, there was a 3-minute baseline. After the baseline, participants were given a 4 × 4 Rubik's Cube to solve for 3 min. Participants were told to complete the blue side of the Rubik's Cube first and then complete the red side. As is typical for assessing ANS reactions to cognitively challenging tasks, the Rubik's Cube was novel and challenging for the vast majority of participants (cf. the star-tracing task) (El-Sheikh et al., 2013). Indeed, only 10 participants completed a single side, and none completed two.

Participants were then instructed to sit still and relax for a three-minute baseline prior to the problem-solving task. After this baseline, they were instructed to attempt to solve a family problem with their parents for 5 min. The family problem was selected earlier in the interview from a list of 28 typical family problems (e.g., finances, media, rules). Reactivity to both the cube and problem-solving tasks are conceptualized as indicative of the adolescents' general stress reactivity to cognitively and socially challenging tasks (Salomon et al., 2000). A larger description of this task can be found in the supplementary materials.

RSA and SC Data Acquisition and Reduction

The Respiratory Sinus Arrhythmia (RSA) and Galvanic Skin Conductance (SC) data was collected, extracted, and cleaned using MindWare data capturing equipment and software (<http://www.mindwaretech.com>). The standard methods for acquiring RSA and SC were followed, including electrode placement (Fowles et al., 1981). RSA was derived in accord with recommendations of the Society for Psychophysiological Research committee on Impedance Cardiography (Berntson et al., 1997). RSA-R and SC-R reactivity was obtained by subtracting baseline RSA-B and SC-B levels from levels during the cube and the problem-solving tasks. These four physiological measurements were used in the final model. A larger description of this method can be found in the supplementary material.

In analyses we used reactivity over the entire session which encompassed cognitively and emotionally challenging tasks. Using reactivity to the entire session provides a generalized indicator of sensitivity to context. Given the moderating effect of sensitivity to context on the relationship between video games and outcomes is likely not restricted to one form of sensitivity (e.g., emotional, cognitive) the broadest measure of sensitivity to context was used, rather than restricting reactivity to a single type.

Analysis Plan

A growth curve model of aggressive behavior in Mplus (version 8.8) will first be conducted. If there is significant variance in the intercept, slope, or quadratic, these variables will be exported for each individual and merged with the larger data set. A series of mixture regression models using LatentGOLD will then be conducted, and a number of fit indices will be explored, including the BIC, AIC, AIC3, Entropy, VLMR and LL difference tests, to determine the best-fitting model. The primary dependent variables are the growth parameters (intercept and slopes), with the primary independent variable indicating levels of violent video game use (no video games at all, low, moderate, and high). Classes will be identified based on the varying ways violent video game use is related to the growth parameters. Class membership will then be predicted by violent video game use along with our other predictors: gender, race, income, maternal warmth and hostility, media monitoring, bullying, self-regulation, physiological indicators (RSA-B, RSA-R, SCL-B, SCL-R), family stress, depression, video game addiction, and relational aggression. In effect, this method will allow the researchers to examine whether playing violent video games predicts aggression levels over time, for whom, and at what level.

Results

See Table 1 for descriptive statistics for most major variables. In general, aggression was relatively low and decreased over time. Table 2 shows bivariate correlations between major variables.

Using Mplus (version 8.8), a growth curve analysis of physical aggression was conducted over the eight waves. The analysis showed good fit and suggested that most adolescents tend to start at low to moderate levels of aggression that remain relatively stable over time ($\chi^2(27) = 97.46$, $p < 0.001$, CFI = 0.964, TLI = 0.963, RMSEA = 0.073). Additionally, the analysis suggested significant variance in the intercept ($B = 0.59$, $p < 0.001$), slope ($B = 0.06$, $p < 0.001$), and quadratic ($B = 0.001$, $p < 0.001$). These variables (intercept, slope, and quadratic) for each individual were exported from Mplus into the larger data set.

Next, LatentGOLD was utilized to conduct a mixture regression. Six separate models were run and fit indices were compared for each model as previously described (see Table 3 for the model comparison). The five-class solution tends to have slightly better model fit than the four-class solution; however, one of the classes included less than 10% of the total participants and added little to the

Table 1 Descriptive statistics for main variables

Variable	Mean	Standard Deviation	Range
Aggression (3)	2.07	0.90	1–5
Aggression (4)	2.01	0.88	1–5
Aggression (5)	2.11	0.89	1–5
Aggression (6)	2.03	0.86	1–5
Aggression (7)	1.93	0.84	1–5
Aggression (8)	1.91	0.86	1–5
Aggression (9)	1.86	0.80	1–5
Aggression (10)	1.80	0.75	1–5
Video Game Violence (3)	5.76	4.91	0–25
Parental Warmth (3)a	0.00	0.60	–2.10–0.83
Parental Hostility (3)a	0.00	0.73	–1.22–2.48
Bullying Victimization (3)a	0.00	0.21	–0.16–1.04
Media Monitoring (3)a	0.00	0.39	–1.29–0.57
Self-regulation (3)a	0.00	0.41	–0.94–1.40
Depression (3)	1.88	0.44	1–4
Stressful Life Events (3)	1.65	1.32	0–14
IGD Symptoms (5)	1.65	1.91	1–11
Relational Aggression (4)	1.85	0.65	1–5

Note: Number after the variable indicates the wave of measurement. Physiological variables are not included in the descriptive table to reduce complexity

^aTo remove measurement error, these were created as latent variables and factor scores saved for analyses. Therefore their means are zero

interpretation. Accordingly, the four-class solution was selected as the final model for parsimony.

Figure 1 shows the final model. Each class is now described in conjunction with its profile, beginning with those classes who have the highest risk for aggressive behavior over time. See the Supplementary Materials for full model statistics for each class.

Class 2 (28%, $n = 137$) began with high levels of aggression with relatively stable levels over time. This class of video game players was more likely to be male, Non-White, and from low-income families. These players tended to have major risk factors for aggressive behavior, including high maternal hostility, high levels of family stress, high likelihood of being bullied, and high levels of relational aggression. This group is called “Multi-risk.” Violent video games appeared to be rather complex in terms of prediction for this class; around 75% of these individuals played no or low amounts of violent video games in the first place. However, the intercept was significantly higher for individuals with moderate video game use, meaning individuals in this class started at higher levels of aggression if they played moderate levels of violent video games. Playing moderate violent video game usage at an individual level was also related to a significantly steeper decline over time.

Class 4 (13%; $n = 62$) also began with high levels of physical aggression. However, instead of declining over time, this group’s trajectory is more curvilinear, with aggression slightly increasing over several years before slightly declining. This group had fewer risk factors than Class 2. They experienced low levels of bullying, and had high levels of behavioral self-regulation. Additionally, they had a lower SCL-R, which indicates a physiologic profile that shows low reactivity to stress. However, this group had the highest levels of video game addiction and were also high on relational aggression. This group is called “High Gaming, High Aggression.” Additionally, playing moderate levels of violent video games was associated with being in the class; Indeed, 69% of individuals in this class were either high or moderate in their violent video game use, far higher than the other three classes. The intercept of this group also showed significant variance, with individuals who played the highest levels of violent video games tending to have the highest initial levels of aggressive behavior. However, there were also some nuanced findings with the slope, in which these same individuals’ aggressive behavior also decreased more quickly over time.

Class 1 (37%; $n = 188$) started at moderate levels of aggression that tended to remain moderate, although slightly decreasing over time. This group tended to be male and White. Though they had lower levels of self-regulation, they also had high levels of parental media monitoring. This group is called “Moderate Risk.” Individuals who had moderate usage of violent video games had a steeper increasing trajectory (with less curve) over time.

Finally, Class 3 (22%; $n = 109$) had very low levels of aggression that remained low over time. This group was more likely to be female (64%) and White (91%) than any other group. Additionally, members of this group came from families with the highest incomes. Though they tended to have lower self-regulation, they also had low maternal hostility and the lowest household stress. Furthermore, this group had the lowest levels of video game addiction and relational aggression. This group is called “Low Risk, High Privilege.” Playing violent video games was not associated with either the intercept or the slope for this group.

All results for all classes can be found in the supplementary materials.

Discussion

Existing research on violent video games focuses on between subjects comparisons, typically consisting of cross-sectional or short-term studies without taking into account the wider context of the individual. This has led to contention in the field concerning the impact of violent video games on aggressive behavior (e.g., Ferguson and Kilburn,

Table 2 Correlations between major variables

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	
1. Aggression (3)	–																					
2. Aggression (4)	0.63**	–																				
3. Aggression (5)	0.55**	0.72**	–																			
4. Aggression (6)	0.46**	0.55**	0.64**	–																		
5. Aggression (7)	0.43**	0.55**	0.52**	0.62**	–																	
6. Aggression (8)	0.39**	0.49**	0.49**	0.57**	0.64**	–																
7. Aggression (9)	0.44**	0.47**	0.49**	0.52**	0.60**	0.65**	–															
8. Aggression (10)	0.42**	0.49**	0.51**	0.52**	0.55**	0.59**	0.67**	–														
9. Video Game Violence (3)	0.16*	0.15*	0.15*	0.12+	0.03	–0.01	0.06	0.06	–													
10. Parental Warmth (3)	–0.37**	–0.22**	–0.24**	–0.23**	–0.18**	–0.17**	–0.24**	–0.16**	–0.14**	–												
11. Parental Hostility (3)	0.39**	0.26**	0.25**	0.23**	0.25**	0.20**	0.26**	0.23**	0.05	–0.47**	–											
12. Bullying Victimization (3)	0.31**	0.21**	0.17**	0.22**	0.23**	0.18**	0.21**	0.23**	–0.01	–0.24**	0.24**	–										
13. Media Monitoring (3)	–0.03	–0.01	–0.03	–0.02	–0.03	–0.02	–0.05	–0.08	0.03	0.10+	–0.04	–0.05	–									
14. Self-regulation (3)	0.26**	0.25**	0.28**	0.26**	0.29**	0.28**	0.24**	0.24**	0.16*	–0.22**	0.14*	0.16**	–0.07	–								
15. Depression (3)	0.29**	0.16**	0.08	0.11+	0.20**	0.17**	0.19**	0.15*	0.02	–0.21**	0.27**	0.41**	–0.04	0.13*	–							
16. Stressful Life Events (3)	0.28**	0.25**	0.18**	0.13*	0.21**	0.14*	0.17**	0.19**	0.12+	–0.30**	0.35**	0.21**	–0.04	0.15*	0.31**	–						
17. IGD Symptoms (5)	0.14*	0.11+	0.16**	0.22**	0.14*	0.07	0.13*	0.20**	0.34**	–0.13*	0.04	0.04	–0.03	0.23**	0.05	0.10+	–					
18. Relational Aggression (4)	0.26**	0.41**	0.36**	0.25**	0.25**	0.25**	0.17**	0.23**	0.02	–0.12+	0.22**	0.22**	–0.04	0.11+	0.18**	0.20**	0.07	–				
19. RSA – B	–0.09	–0.04	–0.02	–0.09	–0.05	–0.05	0.01	–0.02	0.01	0.02	0.01	–0.05	0.07	–0.09	–0.09	–0.01	–0.05	–0.02	–			
20. RSA – R	0.09	–0.02	0.09	0.03	0.03	0.05	0.07	0.02	0.07	–0.14*	0.12+	0.02	–0.04	0.08	–0.01	0.05	0.05	0.01	–0.26**	–		
21. SCL- B	–0.06	0.03	0.01	0.04	0.10	0.02	0.06	0.09	0.05	0.01	0.12+	–0.09	0.01	–0.06	–0.06	0.05	0.25**	0.10+	0.01	0.07	–	
22. SCL- R	–0.01	–0.03	–0.02	0.01	–0.09	0.01	–0.12+	–0.09	–0.07	0.04	–0.07	–0.01	–0.07	0.04	–0.02	–0.10	–0.04	–0.05	–0.02	–0.06	–0.15*	–

Notes: Number behind variable indicates wave

+ $p < 0.05$; * $p < 0.01$; ** $p < 0.001$

2010), leaving many individuals, parents, policy makers, and practitioners at a loss on how to manage violent video games during adolescence. This study utilized mixture regression to examine who is most at risk for developing aggressive behavior over the course of adolescence and under what contexts. We found four classes of adolescents that differed in degree of playing violent video games and trajectories of physical aggression. Violent video game play seemed to contribute less to aggression where there were multiple other risk factors and more to aggression where there were fewer other risk factors. Those more at risk had a complex set of both risky and protective factors. We describe each class in turn and how playing violent video games might impact individual trajectories in each group.

Multi-risk Adolescents

Twenty eight percent of adolescents were labeled as “Multi-risk.” These individuals started with the highest levels of physical aggression of anyone in the sample. Though this group’s level of aggression remained somewhat stable, with a very slight decline throughout adolescence (which is developmentally typical; Piquero et al., 2012), this group also ended with the highest levels of aggression by emerging adulthood. Additionally, this group showed high levels of relational aggression, confirming research that the two forms of aggression tend to co-occur (Card et al., 2008). This group had many risk factors known to be related to

aggressive behavior, including being male (Nivette et al., 2018), having a lower income (Côté et al., 2006), having a mother who showed high levels of hostility (Pinquart, 2017), being victimized by bullies (Walters, 2021), and coming from a chaotic and stressful home environment (Fikkers et al., 2013). In other words, this group of individuals has many risk factors that make them more vulnerable to aggressive behavior, particularly during a vulnerable and sensitive period of development.

This group had a complex relationship with violent video games. On one hand, the individuals in this group who had moderately high usage of violent video games tended to have higher levels of physical aggression at the initial time point (starting at an average of 0.89 points higher than others in the group). This confirms existing research suggesting that youth from high conflict families tend to play a lot of violent video games and also are more likely to be aggressive (Fikkers et al., 2013). However, this class was mostly comprised (75%) of individuals who did not play video games at all or had low usage of violent games. Additionally, the few individuals who did have moderate usage of violent video games had slopes that decreased more rapidly over time than others (at a rate of -0.18 over time). This result may be a ceiling effect, in which adolescents who play moderate levels of violent video games end up at around the same level of aggression as those who do not (but also have similar intensive risk factors). In other words, within this group, playing violent video games might be associated with aggression at younger ages, but this tends to even out by emerging adulthood.

Overall, it appears that playing violent video games does not contribute substantial additional risk to this group, who are already at a very high risk for developing aggression over time. Some of the other risk factors (e.g., victimization, parental hostility, stress in the home) seem more influential, and may overshadow the effect of playing violent video games. Indeed, playing video games may offer a sense of community and some respite from a chaotic family and peer life for these individuals. Together these findings suggest that for this group, it is the confluence of a range of risk factors, not just playing violent games (as Fikkers et al., 2013 found), that contributes to

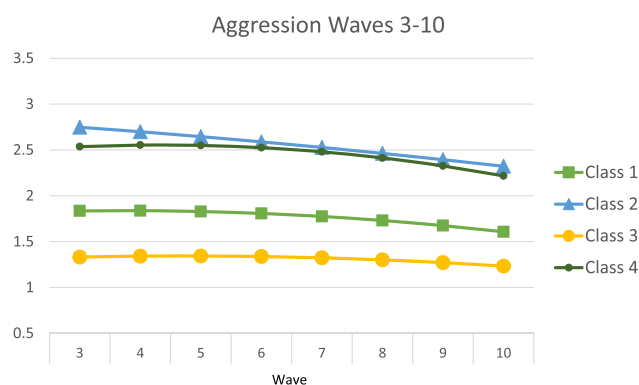


Fig. 1 Mixture Regression for Physical Aggression Over Time

Table 3 Class membership

Model	LL	BIC	AIC	AIC3	VLMR (<i>p</i> value)	LLDiff test (<i>p</i> value)	Entropy
1-Class	1444.1781	−2721.2177	−2834.3562	−2807.3562			
2-Class	1674.6635	−2946.9565	−3219.3270	−3154.3270	0.0000	0.0000	0.8212
3-Class	1751.3893	−2865.1761	−3296.7786	−3193.7786	0.0000	0.0000	0.8448
4-Class	1813.3067	−2753.7789	−3344.6134	−3203.6134	0.0001	0.0000	0.8632
5-Class	1872.1830	−2636.2996	−3386.3660	−3207.3660	0.0012	0.0000	0.8930
6-Class	1916.8641	−2490.4297	−3399.7282	−3182.7282	0.0873	1.0000	0.8950

high levels of aggression. For such high-risk adolescents, focusing solely on the reduction of violent video game play will likely not be effective in interventions to decrease aggression.

High Gaming, High Aggression

The High Gaming, High Aggression group consisted of 13% of our sample and also started at high levels of aggression in early adolescence. Like the previous group, they also showed high levels of relational aggression. However, unlike the other groups, aggression was curvilinear, with a slight peak in later adolescence before declining in emerging adulthood. This group appeared to be most at risk for developing aggressive behavior after playing violent video games. As a direct counterpoint to Class 2 (Multi-risk adolescents), the majority of this group were either moderate or high on violent video game play (nearly 70%). Indeed, individuals in this group who played high-violence video games started at the highest levels of physical aggression compared to other adolescents. However, there was some nuance to this finding, with aggression in individuals playing high-violence video games decreasing faster than in others in the group. Examining the individual parameters (see supplementary information) provided some insight into this seemingly contradictory finding: individuals who played violent video games at the initial time point scored more than a full point higher (1.02) than others in the group in aggressive behavior at the beginning of the study. Aggressive behavior decreased over time, but only at a rate of 0.34. Thus, the individuals who started with these higher aggression levels likely remain just as aggressive (or even more so) than other individuals. Additionally, the slope was positive for those who did not play video games at all (with an increase of 0.21), meaning they were more likely to increase in aggressive behavior over time (though the rate of increase was quite small). This may be a result of other, more prominent factors, including their physiology, mental health, or the age they began playing video games. Regardless, there tends to be considerable nuance with this group.

Unlike the Multi-risk group, this class had several protective factors, including high behavioral self-regulation and low levels of bullying. However, this group also showed high levels of IGD and high depression (which tend to be comorbid; Marshall et al., 2022). Thus, individuals in this group tended to experience greater dysfunction in relation to video games in general, and they likely used gaming as a way to cope with mental health. Additionally, this was the only group for whom physiological reactivity (specifically, a low SCL-R) was a significant predictor. This physiologic profile indicates a sympathetic nervous system (anxiety and

fear) that tends to show low reactivity when confronted with a stressor. This type of profile has been associated with aggressive and antisocial behavior (e.g., Susman, 2006) and might be a major reason why this particular group showed high levels of physical aggression over the course of adolescence.

Given the brain development that occurs during adolescence, combined with a physiologic profile that shows a lack of reactivity to stress, high usage of violent video games early in this development period may trigger physical aggression over time. Thus, reducing violent video game play may be moderately successful in reducing aggressive behavior over time for this particular group.

Moderate Risk

The Moderate Risk group was our largest class, encompassing 37% of adolescents in our sample. This group tended to show moderate levels of physical aggression that declined over the course of adolescence. Compared to the other groups, there were few predictors for this class (meaning they tended to center around average for most measures). However, this group was more likely to be male and Non-White and show poor behavioral self-regulation, which tends to predict aggressive behavior (Connor et al., 2019; Moore et al., 2019). However, group members' parents also showed higher levels of media monitoring, meaning they were more likely to keep their media (including violent video games) in check. Parents of these group members were also more likely to discuss media content with their children, increasing critical viewing skills in these individuals.

Playing violent video games at any specific level did not predict being in this group, and the level of violent gaming did not predict initial levels of aggression. However, playing moderate levels of violent video games was associated with a steeper, increasing slope across adolescence, though final levels of aggressive behavior remained low to moderate during emerging adulthood. It is likely that the combination of being male, playing violent video games in early adolescence, and having low self-regulation may increase the likelihood of individual aggressive behavior, making these individuals particularly susceptible compared to other adolescents (Valkenburg and Peter, 2013). Given that these individuals did not have some of the more severe risk factors as other adolescents in our sample (and even had several protective ones), violent video games tended to hold greater weight for certain individuals in this group. Thus, reducing playing violent video games might have a modest impact on aggressive behavior over time for this particular group. However, given that their aggressive behavior was fairly low over time, this group is less concerning than others in the sample.

Low Risk, High Privilege

Finally, 22% of adolescents as “Low Risk, High Privilege.” These individuals had by far the lowest levels of physical aggression, which remained stable over the course of adolescence. They also had very low levels of relational aggression at the initial time point. In other words, this group was simply almost never aggressive throughout adolescence. The majority of members of this group were female, White (90%), and high in SES. They had parents with low hostility, and they came from families with the lowest amounts of stress and chaos. Though they had slightly lower levels of self-regulation than other groups, they had enough protective factors that aggressive behavior was not likely to occur.

Additionally, almost 80% did not play video games or played low-violence video games. On an individual level, playing violent video games had no measurable impact on initial levels or increase in aggressive behavior across a decade. In other words, these individuals were privileged enough and had enough protective factors that even playing tremendously violent video games was not related to aggressive behavior, either in the short or long term. Thus, in terms of individual susceptibility to negative effects from playing violent video games, this group was extremely low (Valkenburg and Peter 2013).

Implications

The key implication of this research relates to the prevention of and intervention in adolescent aggressive behavior. Our findings highlight the importance of disentangling the different individual, familial, peer, and media influences on adolescent aggressive behaviors across developmental periods. A recent meta-analysis of interventions to reduce aggressive behavior in adolescents found that interventions were most effective when they targeted high-risk adolescents rather than a general adolescent population (Castillo-Eito et al., 2020). Not all violent media has the same impact on individuals, and therefore, a specific and targeted intervention approach was necessary for this study. Overall, our results suggest that adolescents who experience high victimization, parental hostility, and familial stress are at greatest risk for a high, enduring trajectory of aggressive behavior. Thus, targeting these factors alongside efforts to reduce aggressive behavior is key. It is noteworthy that exposure to violent video games differentially affected each group of adolescents. Indeed, high violent video game play did not always add risk, and instead decreased aggression for some of our highest risk adolescents. This finding should be carefully considered in intervention efforts that discourage or remove violent media from adolescents.

Limitations

There were a few notable limitations in this study. Most prominent was the self-report of aggressive behavior. This measure likely had some level of bias and future research should measure aggression through other methodologies (e.g., peer, teacher, parent reports) to confirm these results. Additionally, participants were from a relatively small sample (in a somewhat privileged area) in the northwestern United States. It is possible that results may be different with more diverse samples. Several measures were collected after the initial wave of aggression, namely relational aggression, physiological reactivity, and pathological video game use. Though these measures are relatively stable over time, it would have been ideal to include them at the initial wave of measurement. Thus, these variables should be viewed with some caution. Furthermore, there is always some bias when doing longitudinal media research since technology improves over time. Thus, it is possible that a study that started today would find different results given that video game violence is likely portrayed differently than more than a decade ago when the study was initiated. Finally, the context of the video game was not measured, only the level of violence. Other research has found that context matters; games that are played in a competitive (as opposed to cooperative) manner (Verheijen et al., 2019) and games that are highly frustrating (Deville et al., 2021) tend to elicit higher levels of aggressive behavior. Thus, individual risk likely interacts with the context of the game, and future research should consider including gaming context in examinations of individual susceptibility.

Conclusion

The extant research on violent video games and aggression has not clearly indicated individual risk during adolescence. This study found that overall, playing violent video games was associated with aggressive behavior but in a nuanced and complex way. Notably, having either many risk or many protective factors tended to decrease the likelihood of the individual developing aggressive behavior as a result of playing violent video games. Even though aggression differed dramatically between these two particular groups, *it likely was not a result of violent video game play*. Conversely, a small percentage of individuals who experienced other problems with video games and struggled with mental health and who also had physiologic profiles that primed them for aggressive behavior seemed to be the most susceptible to violent video game effects. To a lesser extent, males with low self-regulation also showed some susceptibility, though the high media monitoring from their parents likely mitigated any severe negative effects of violent game

play. Researchers, parents, teachers, and policy makers might best decrease aggressive behavior by focusing on violent video game usage by those who are most susceptible while targeting and reducing potential risk factors (e.g., poverty, parental hostility, parent incarceration, etc.). It is hoped that this research provides a balanced perspective of research on violent video games, which clearly do not affect everyone the same way, ultimately helping the field to “level up”.

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Compliance With Ethical Standards

Conflict of Interest The authors declare no competing interests.

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