Computers in Human Behavior 109 (2020) 106355

Contents lists available at ScienceDirect

Computers in Human Behavior

journal homepage: http://www.elsevier.com/locate/comphumbeh

Videogames and guns in adolescents: T ests of a bipartite theory

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ARTICLE INFO

Keywords:
Video games
Technology and society
Guns
Adolescents
Imprinting hypothesis
Displacement hypothesis

ABSTRACT

The possible role of video gaming in imprinting aggressive and specifically gun-related behaviors has been elusive, and findings regarding these associations have been inconsistent. I address this gap by proposing and testing a *bipartite theory* that can explain inconsistent results regarding the previously assumed linear association between videogames and gun-related behaviors. The theory suggests that this association follows a U-shape. It posits that at low levels of video gaming time, video gaming displaces gun-related behaviors and shelters adolescents by keeping them occupied and by reducing opportunities and motivation to acquire guns. However, at some level of gaming time (because most popular games adolescents play include violent aspects), the assumed imprinting of aggressive behaviors overpowers the positive displacement force, and this can trivialize and naturalize gun-carrying behaviors, and ultimately increase motivation to obtain and carry guns. I tested this theory with two national samples of American adolescents ($n1 = 24{,}779$ and $n2 = 26{,}543$, out of which 403 and 378, respectively, reported bringing a gun to school in the last month). Multiple analyses supported the proposed U-shaped association. These findings show that the moral panic over video games is largely unsubstantiated, especially among light to moderate gamers.

1. Introduction

Video gaming is prevalent among US adolescents (people in the 10–19 age range based on World Health Organization (WHO)) (Bassiouni, Hackley, & Meshreki, 2019); 72% of them play video games (84% in boys, and 59% in girls) (Lenhart, Smith, Anderson, Duggan, & Perrin, 2015). Playing videogames can have positive effects on adolescents, including improved motor skills, selective visual attention, and cognitive abilities ((He, Turel, Wei, & Bechara, 2020); Turel, He, Wei, & Bechara, 2020); serious games can also be used for learning, skill development, and fun (Padilla, Ochoa, & Margain, 2016), and help children with mental disorders to develop desired skills (Mansilla et al., 2017). Nevertheless, there is some but inconclusive evidence that leisure video games, many of which are plagued with violence (Greitemeyer, 2018), can be weakly but significantly associated with aggressive behaviors (Bushman & Anderson, 2002; DeWall, Anderson, & Bushman, 2011; Elson & Ferguson, 2014). While such studies have focused on various forms of aggression, little is known about how the use of video games might be associated with gun-related behaviors in adolescents. Examining this association is important, given recent school shooting incidents in the US, and the ability of scientific findings to guide policy development, and prevention efforts (Clements, 2012). Findings on this association can also inform research because research on this topic has been inconclusive (see discussion in Supplementary Materials A). This body of rsearch has also primarily focused on negative effects of video games, neglecting their potential positive effects (American Psychological Association, 2015). Here, I aim at providing and supporting a more balanced than before perspective on this association.

The current state of knowledge on this topic is that there may be many drivers of gun-related behaviors in adolescents (e.g., social-economic status, peer pressure, access to guns, media coverage) (Porfiri, Sattanapalle, Nakayama, Macinko, & Sipahi, 2019), but videogames, especially violent ones, can be a small but significant contributing factor (Bushman & Anderson, 2002; DeWall et al., 2011). I seek to extend the understanding of this association and inform the debate about it, by focusing not only on the possible negative role of video games in this association but also potential positive effects of video gaming in this context.

I specifically focus on carrying a gun to school as the variable of interest for three reasons. First, it is a preliminary and necessary condition for gun violence at schools. Second, it is likely easier to intervene with this behavior than with the actual use of the firearm at school.

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https://doi.org/10.1016/j.chb.2020.106355
Received 30 October 2019; Received in revised form 2 March 2020; Accepted 23 March 2020
Available online 29 March 2020
0747-5632/

Third, for convenience reasons - the data include self-reports of this behavior and not of actual behavior. I note that carrying guns can, in some cases, increase safety and reduce violence (Lott, 2013). But adolescents carrying guns to school increases the risk of aggression, psychological harm, traumatic stress, injuries and death, through perpetrating attacks, victimization, threatening others, retaliation, and suicide attempts (Cukier & Eagen, 2018). Such issues exist in many countries but are especially pronounced in the United States (US) with its gun availability and culture (Kalesan, Villarreal, Keyes, & Galea, 2016). Indeed, 1.4% of high school students reported bringing a weapon to school in the last month in a US study, out of which 33% said the weapon was a gun (Ybarra, Huesmann; Korchmaros, & Reisner, 2014).

1.1. *Bipartite theory of association between video-gaming and gun-related behaviors*

I posit that inconsistent prior findings (See Supplementary Materials A) may stem from the assumed negative role of videogames, which ignores possible nuanced complexities of this association. I specifically consider possible nonlinearity of this association by suggesting a *bipartite theory* that integrates the "*displacement hypothesis*" (Gentile, 2011) with the "*imprinting through repeated exposure*" hypothesis (Anderson et al., 2010). This *bipartite theory* suggests that "light" to "moderate" gaming can be a positive force that reduces gun-carrying behaviors (compared to not playing video games). However, at high levels of video gaming time, the stronger imprinting of aggressive behaviors becomes feasible, and can overshadow the positive displacement effect. Combined, these hypotheses imply a U-shaped association between video gaming time and carrying guns to schools (see Fig. 1).

*Hollow arrows reflect theory relevance and dominance in the examined range of video gaming time. The direction of arrow expresses the direction of influence of video gaming time on the frequency of bringing guns to school that is consistent with the theory that is dominant in the examined range.

I provide preliminary evidence in support of this bipartite association by analyzing two secondary cross-sectional datasets from a nationally representative sample of American adolescents collected from 2012 to 2017 (Monitoring the Future, see Miech, Johnston, Bachman, O'Malley, & Schulenberg, 2019), out of which 781 (1.5%) reported bringing a gun to school in the last four weeks. The first dataset includes 2012–2014 data (n = 24,779) and the second includes 2015–2017 data (n = 26, 543). These data were selected for several reasons. First, I focused on adolescents given their tendency to engage in risky behaviors, including gun-related behaviors (Klein et al., 1993); this behooves researchers and policymakers to find ways to reduce them. Second, as mentioned above, gun culture and accessibility in the US make gun-carrying to school easier to implement compared to in other countries (Ybarra, Huesmann, Korchmaros, & Reisner, 2014). Lastly, for convenience reasons, the employed datasets include a large sample of US adolescents that have reported both video gaming and gun-carrying behaviors.

1.2. *Hypothesis development*

I first note that the association between videogames and aggression is typically explained via the general aggression model (Bushman & Anderson, 2002; DeWall et al., 2011). This model suggests that aggressive behaviors are triggered in social encounters based on repeated person-environment interactions that create knowledge structures (or scripts), which include aggression as a desirable, normal, and acceptable response to threats in the environment. When such scripts are established, people can develop hostile attribution bias, which leads them to assess ambiguous social situations as much more threatening than they really are, and respond to them with aggression (Crick & Dodge, 1996). Thus, when aggression scripts are imprinted in individuals, individuals tend to accentuate threats in the environment and act accordingly (Dill, Anderson, Anderson, & Deuser, 1997). Applied here, it means that repeated exposure to guns, gun use, and violence, can normalize such objects and behaviors in adolescents' minds and make them seem like natural and even necessary. At the heart of this association is the assumption that most videogames include violent features, which are the basis for imprinting violent behaviors. I test this assertion in a preliminary study of 99 11th grade US high school students (66 male, 33 female) who play videogames. Results (see Supplemental Materials B) show that even though games vary by audience rating, most popular games contain blood, violence, shooting, and weapons. Thus, they have the potential to imprint violent behaviors, including gun-related behaviors.

Nevertheless, the "imprinting through repeated exposure"

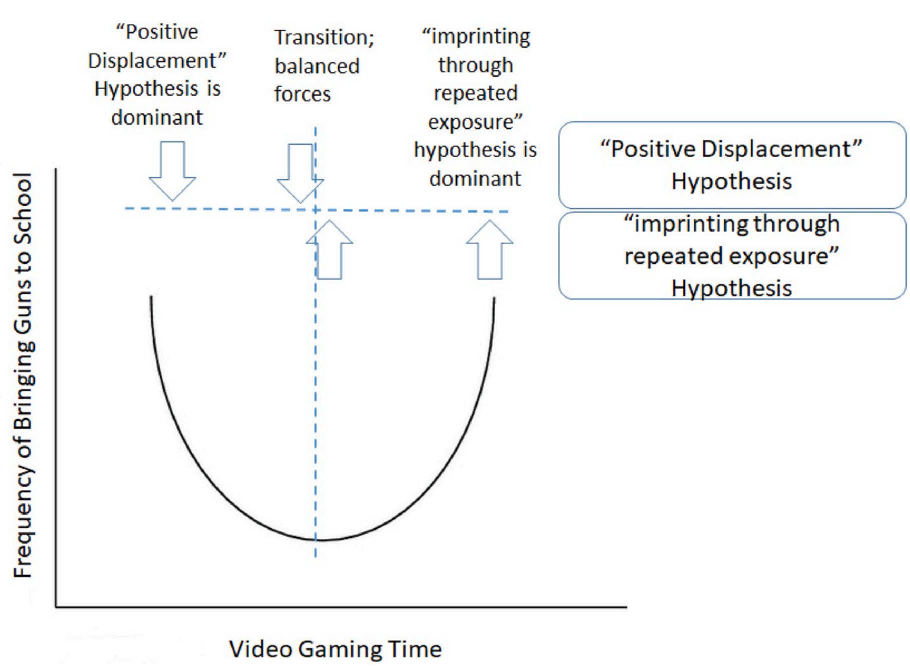

Fig. 1. Research Model and its Theoretical Underpinnings*.

hypothesis is likely relevant only at high levels of repeated exposure. While a single exposure is sufficient for creating short term effects on immediate aggressive cognitions and behaviors (Bushman & Anderson, 2002), it takes frequent and prolonged repetition to create significant relatively stable changes in a person's aggressive personality, as manifested in more aggressive behavioral schemata (Anderson et al., 2017). This is consistent with key ideas of attitude and behavior change models (Ajzen, 2001; Fishbein & Ajzen, 2011), according to which changes require prolonged and persistence exposure to change instigators. When video gaming time is low, possible aggressive cues in games may not suffice for creating significant changes in aggression (gun-related in our case) schemata (Lemmens, Valkenburg, & Peter, 2011). Thus, I hypothesize that (**H1**) only when video gaming time is sufficiently high (to be empirically defined later), there is a positive association between video gaming time and bringing guns to school.

To supplement this perspective, I build on the displacement hypothesis. It suggests that when there are physical, spatial, or temporal constraints that do not afford simultaneous execution of activities, one activity may be displaced by another, more appealing, or advantageous activity (Gabor, 1981). For example, when gun availability is low, other means of suicide displace them (Carrington & Moyer, 1994). In the case of video gaming, research often built on the displacement hypothesis to suggest that time spent on video gaming displaces and detracts from other important activities (Gentile, 2011), such as school work (Sharif & Sargent, 2006) and physical activity (Biddle, Gorely, Marshall, Murdey, & Cameron, 2004) (dubbed here *negative displacement*). Nevertheless, video gaming can also serve as a *positive displacement* by keeping adolescents occupied. This activity prevents them from having the motivation and/or opportunity to hang out on the streets and indirectly, have a need, motivation to acquire or carry, and access to guns. There is some evidence for such positive displacement with regards to illicit substances; "light" gamers use illicit substances less frequently compared to non-gamers and compared to "heavy" gamers (Turel & Bechara, 2019).

While the displacement hypothesis may be relevant in the entire continuum of video gaming time, and its effect grows as playtime increases, the absence of aggression imprinting forces at low levels of gaming makes the displacement hypothesis more dominant at low levels of video gaming time. This *positive displacement* means that video games can serve as a healthy substitute to unsupervised after-school time (that can give rise to motivation and opportunity to access guns), without much influence of imprinting forces. Videogames, at this level, can displace gun behaviors indirectly. Specifically, they can alleviate precondition factors for gun carrying to school (e.g., hanging out with people who sell and/or play with guns, hanging out and feeling threatened on the streets, socializing with the wrong people after school). This level of video gaming can also represent "voluntary incapacitation," a term describing how people selectively choose an activity that prevents them from engaging in problematic behaviors (Dahl & DellaVigna, 2009). Integrating these views, I hypothesize that (**H2**) as people transition from not playing video games to low video gaming time, there is a negative association between video gaming time and bringing guns to school.

H1 and H2 describe competing forces; while H1 focuses on high levels of video gaming and the imprinting force, H2 focuses on low levels of video gaming and the displacement force. The dominance of these competing forces should, therefore, inflect at some point along the video gaming time continuum. The integration of these forces suggests that video gaming contributes to declining gun-carrying behaviors (consistent with the *positive displacement* hypothesis) until an inflection point, where the imprinting hypothesis overshadows the displacement effect, and the association between video gaming and bringing guns to school becomes positive. I hence expect that (**H3**) the association between video gaming time and bringing guns to school is U-shaped, such that it is negative at low levels of video gaming time and positive at high levels of video gaming time.

2. Methods

2.1. Study design

I used secondary data from 2012 to 2017 national surveys (Monitoring the Future, see Miech et al., 2019) of eighth and tenth-grade students collected during class time at middle- and high-schools. Study procedures were approved by the Institutional Review Board of the University of Michigan. Data were collected after coordination with school administration, and after obtaining consent from parents and assent from the minor children. Surveys were fully anonymized such that sensitive data are freely reported. The survey runs annually in eight grade (middle school; typically, 13–14 years old) and tenth grade (high-school, typically 15–16 years old). The 2012–2017 datasets were obtained by sampling schools within geographic sampling units, from all US states, such that nationally representative samples in terms of race, sex, and geography are collected. The six-year sample was divided into two distinct three-year samples in order to afford replication and increase validity in the findings (Osatuyi & Turel, 2020).

The independent variable (daily video gaming time) was measured by asking adolescents to report how many hours per week they play video games on any device (computer, phone, TV, or other). Responses ranged from 1 = none to 9 = ≥40 h. To avoid relying on the artificial equal distances between scale points, they were converted into estimated hours per day. Range values (e.g., 6–9 h) were re-coded as the middle point (i.e., 7.5 h in the example), and the result was divided by seven to convert from weekly to daily time (Bradbury, Turel, & Morrison, 2019). Squared values were calculated to model the hypothesized quadratic association. The dependent variable (frequency of bringing a gun to school) was captured in a different part of the survey by asking adolescents to report the number of days during the last four weeks on which they brought a gun to school. Responses ranged from 1 = none to 6 = ≥10 days. For proper scaling, similar conversions to those applied to the independent variable were employed here. For example, the value "3–5 days" was recoded as 4 days. For a supplementary analysis focusing on video gaming association with the odds of bringing guns to schools, a dummy variable was created (Turel, 2020), such that 0 represented not bringing a gun to school over the last 4 weeks and 1 described bringing a gun to school in the previous 4 weeks, at least once.

Several control variables that may be relevant were included: year of administration (2012–2017), sex (0 = female, 1 = male), grade (0 = 8th grade, 1 = 10th grade), mother and father highest level of schooling (from 1 = ≤ Grade school, to 6 = Graduate or post-college professional school) and average daily hours of TV (based on weighted average of self-reported weekday and weekend hours of TV). Year of administration was included to account for trends in gun violence prevalence in the US (Frazer et al., 2018). Sex was included because the sexes differ in both video gaming patterns and choices (Lucas & Sherry, 2004) and weapon-related behaviors (DuRant, Krowchuk, Kreiter, Sinal, & Woods, 1999). Grade was included as a proxy for age, because assaults with weapons and injuries from such assaults increase from the age of 2 to the age of 17 (Finkelhor, Turner, Ormrod, & Hamby, 2009). The family environment and socioeconomic status were indirectly captured with parent education (Johnson, Cohen, Smailes; Kasen, & Brook, 2002). Lastly, TV time is another activity that can potentially displace violent behaviors at low levels but may be less likely to imprint violent behaviors at high levels (Markey, Markey, & French, 2015; Swing, Gentile, Anderson, & Walsh, 2010). I hence control for it and its squared value.

2.2. Sample

Descriptive statistics for the sample are given in Table 1.

* Given that the survey has hundreds of variables, each participant completed a predefined subset of the full survey. Thus, not all records include surveys in which all variables of interest were measured. The operational sample includes only complete records (i.e., records that

Table 1
Sample characteristics.

	2012	2013	2014	2015	2016	2017	Total
Sampled Schools	268	263	255	261	252	237	1536
Student Response Rate [%]	89.02	89.07	89.06	87.96	89.07	86.06	88.37
Obtained Sample [Adolescents]	31,106	28,495	28,536	31,162	32,873	30,181	182,353
Operational Sample*	8873	7987	7919	8885	9188	8470	51,322
Grade distribution [% 8th]	48.0	50.1	50.1	45.7	51.4	51.4	49.4
Sex distribution [% Female]	51.7	51.3	52.4	51.4	51.6	50.4	51.5
Video gaming time [hours per Day] (SD)	1.27 (1.69)	1.43 (1.81)	1.53 (1.88)	1.46 (1.82)	1.48 (1.81)	1.48 (1.81)	1.43 (1.80)
Father Education Level (SD)	4.08 (1.41)	4.03 (1.43)	4.01 (1.43)	4.07 (1.42)	3.98 (1.43)	3.94 (1.46)	4.02 (1.43)
Mother Education Level (SD)	4.29 (1.33)	4.22 (1.36)	4.25 (1.36)	4.29 (1.36)	4.22 (1.39)	4.19 (1.42)	4.24 (1.37)
Hours of TV/Day (SD)	2.09 (1.33)	2.07 (1.35)	2.05 (1.36)	1.92 (1.35)	1.88 (1.37)	1.78 (1.35)	1.96 (1.36)
Bringing guns to school [%]	1.8	1.7	1.4	1.3	1.4	1.5	1.5

have no missing values for the model variables).

2.3. Statistical analysis

All analyses were performed in SPSS 25, separately for the 2012–2014 (n = 24,779) and 2015–2017 (n = 26,543) datasets. All models were estimated with bootstrapping with 1000 re-samples for generating bias-corrected 95% confidence intervals for estimates. This was done to avoid distributional assumptions, for better assessing estimate robustness (Mooney & Duval, 1993), and for allowing the comparison of regression coefficients. I performed three analyses. First, a preliminary examination of the hypothesized U-shaped association was performed by plotting the 95% confidence intervals for the frequency of bringing guns to school at different levels of daily video gaming time. Non-overlapping confidence intervals or distances from upper/lower bound to the estimate point that have <50% overlap were deemed indicative of significant differences at least at the $p < 0.05$ level (Cumming, 2009). Second, I tested the hypotheses directly with hierarchical regression models (Turel & Gil-Or, 2019), where the first block included control variables, the second added video gaming time, and the third added squared video gaming time. This approach allows testing nonlinear associations after accounting for control variables, and for examining the added contribution of predictors. Last, I supplemented the testing of the hypotheses and expanded the regression model interpretation with a logistic regression model that focused on the associations between the predictors and the odds of bringing a gun to school. The dependent variable in this case was binary (brought a gun to school or not), which required the use of logistic regression.

3. Results

Fig. 3 depicts a consistent association pattern between daily video gaming time and the frequency of bringing a gun to school in the last four weeks. For both datasets, it indicates a statistically significant decline in this behavior from the group that does not play video games to those who play video games for as little as 0.07 h per day. The displacement and imprinting forces appear to relatively balance each other between 0.07 h of video gaming per day and 4.93 h per day, and the imprinting of aggressive behaviors seems to overpower the displacement force only after about 5 h of video gaming per day. Results therefore, provide preliminary support for the bipartite theory and the hypothesized U-shaped association.

Table 2 outlines the results of the hieratical regression and logistic regression models for the first dataset; Table 3 does so for the second dataset. The hieratical regression results, consistently across datasets, support the hypothesized U-shaped association between video gaming time and bringing a gun to school. They show that this association is small but significant, even after controlling for several essential confounds. The coefficients indicate that video gaming initially decreases the frequency of bringing a gun to school (consistent with the “positive displacement” hypothesis) and that the frequency of bringing a gun to school does not increase until the vertex of the parabola is reached. The inflection point is 2.14 h/day in the 2012–2014 data and 2.63 h/day in the 2015–2017 data.

Results also show that TV time does not play the same role as video gaming. In both datasets, gun-carrying was not associated with TV time and squared TV time, when video gaming time was included. Based on confidence intervals, the associations between squared video gaming time and gun carrying was significantly larger than this between squared TV time and gun carrying in the 2012–2014 data but not in the 2015–2017 data. In terms of other controls, in both datasets, males reported significantly higher levels of gun-carrying compared to females. The samples differed in the trend of gun-carrying to school: this behavior significantly decreased between 2012 and 2014, but changes from 2015 to 2017 were not significant. Older adolescents had increased frequency of bringing a gun to school in 2012–2014 data, but this trend, while existed, was not significant in the 2015–2017 data. Lastly, the father’s education level contributed to a reduction in gun carrying behaviors only in the 2015–2017 data.

A similar view, but with a focus on odds, is conveyed by the logistic regression results. These results consistently across datasets also support the hypothesized bipartite theory with the logit function and the significant squared-term. The vertex of this function is 2.34 h/day for 2012–2014 data and 2.82 h/day for the 2015–2017 data. That is, video

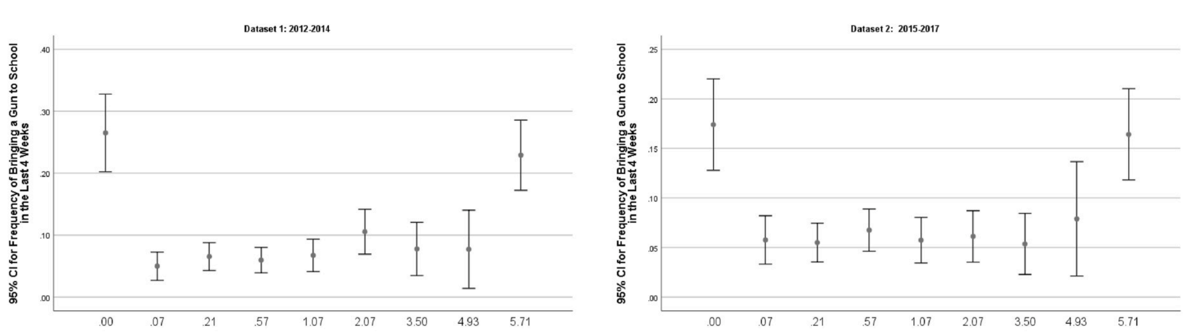

Fig. 3. Bi-variate Association between Daily Video Gaming Time and Frequency of Bringing a Gun to School*. *Bars represent 95% confidence intervals.

Table 2
Regression models estimates – 2012–2014 dataset[a,b,c]

	Hierarchical Regression Model (n_1 = 24,779)			Logistic Regression Model
Predictor	Block 1	Block 2	Block 3	
Year of Administration	−0.015 (−0.028; −0.001) p < 0.015	−0.017 (−0.030; −0.003) p < 0.008	−0.017 (−0.030; −0.002) p < 0.01	−0.156 (−0.303; −0.016) p < 0.026, Exp(β) = 0.855
Grade	0.031 (0.007; 0.055) p < 0.013	0.030 (0.006; 0.055) p < 0.013	0.028 (0.004; 0.053) p < 0.019	0.157 (−0.094; 0.4) p < 0.196, Exp(β) = 1.17
Sex	0.126 (0.102; 0.149) p < 0.001	0.124 (0.099; 0.147) p < 0.001	0.130 (0.105; 0.154) p < 0.001	1.673 (1.411; 2.024) p < 0.001, Exp(β) = 5.326
Father Education	0.000 (−0.012; 0.013) p < 0.936	0.001 (−0.011; 0.013) p < 0.863	0.001 (−0.010; 0.014) p < 0.759	−0.049 (−0.169; 0.075) p < 0.450, Exp(β) = 0.952
Mother Education	−0.008 (−0.020; 0.002) p < 0.157	−0.008 (−0.019; 0.003) p < 0.161	−0.008 (−0.019; 0.003) p < 0.163	−0.072 (−0.18; 0.037) p < 0.230, Exp(β) = 0.931
Daily TV	−0.022 (−0.059; 0.010) p < 0.212	−0.020 (−0.056; 0.012) p < 0.263	−0.011 (−0.046; 0.023) p < 0.545	−0.138 (−0.457; 0.158) p < 0.357, Exp(β) = 0.871
$(\text{Daily TV})^2$	0.007 (0.000; 0.015) p < 0.057	0.006 (−0.000; 0.014) p < 0.113	0.004 (−0.002; 0.012) p < 0.232	0.043 (−0.016; 0.102) p < 0.152, Exp(β) = 1.044
Daily Video Gaming		0.013 (0.004; 0.023) p < 0.003	−0.051 (−0.081; −0.024) p < 0.001	−0.514 (−0.876; −0.213) p < 0.001, Exp(β) = 0.598
$(\text{Daily Video Gaming})^2$			0.012 (0.006; 0.017) p < 0.001	0.110 (0.058; 0.167) p < 0.001, Exp(β) = 1.116
$R^{2\,\dagger\dagger}$	0.6%	0.7%	0.9%	6.6%
ΔR^2	0.6% (p < 0.000)	0.1% (p < 0.000)	0.2% (p < 0.000)	NA

[a] Significant values, at least at p < 0.05, are bolded and italicized.
[b] All cells include unstandardized coefficients, bootstrapping-based 95% bias-corrected confidence intervals for the coefficients, and two-sided p-values.
[c] For the logistic regression model, cells also include e^{β} and pseudo R^2 (Nagelkerke R Square).

Table 3
Regression models estimates – 2015–2017 dataset[a,b,c]

	Hierarchical Regression Model (n_2 = 26,543)			Logistic Regression Model
Predictor	Block 1	Block 2	Block 3	
Year of Administration	−0.004 (−0.016; 0.007) p < 0.453	−0.004 (−0.016; 0.007) p < 0.452	−0.003 (−0.016; 0.008) p < 0.506	−0.032 (−0.18; 0.124) p < 0.664, Exp(β) = 0.969
Grade	0.014 (−0.005; 0.034) p < 0.157	0.014 (−0.005; 0.034) p < 0.157	0.013 (−0.005; 0.033) p < 0.177	0.047 (−0.198; 0.323) p < 0.688, Exp(β) = 1.048
Sex	0.091 (0.070; 0.112) p < 0.001	0.091 (0.070; 0.111) p < 0.001	0.097 (0.075; 0.120) p < 0.001	1.407 (1.109; 1.744) p < 0.001, Exp(β) = 4.083
Father Education	−0.011 (−0.021; −0.001) p < 0.034	−0.011 (−0.021; −0.000) p < 0.036	−0.010 (−0.021; −0.000) p < 0.045	−0.162 (−0.289; −0.031) p < 0.011, Exp(β) = 0.850
Mother Education	−0.003 (−0.013; 0.006) p < 0.473	−0.003 (−0.013; 0.006) p < 0.47	−0.003 (−0.013; 0.006) p < 0.483	−0.085 (−0.197; 0.034) p < 0.154, Exp(β) = 0.919
Daily TV	−0.021 (−0.050; 0.007) p < 0.134	−0.021 (−0.050; 0.008) p < 0.149	−0.014 (−0.043; 0.014) p < 0.304	0.001 (−0.335; 0.381) p < 0.993, Exp(β) = 1.001
$(\text{Daily TV})^2$	0.007 (0.001; 0.014) p < 0.025	0.007 (0.000; 0.014) p < 0.028	0.006 (−0.000; 0.012) p < 0.067	0.036 (−0.042; 0.103) p < 0.298, Exp(β) = 1.036
Daily Video Gaming		0.001 (−0.005; 0.009) p < 0.725	−0.053 (−0.075; −0.031) p < 0.002	−0.768 (−1.165; −0.442) p < 0.001, Exp(β) = 0.464
$(\text{Daily Video Gaming})^2$			0.010 (0.005; 0.014) p < 0.002	0.136 (0.082; 0.2) p < 0.001, Exp(β) = 1.146
$R^{2\,\dagger\dagger}$	0.6%	0.6%	0.7%	5.3%
ΔR^2	0.6% (p < 0.00)	0.0% (p < 0.669)	0.1% (p < 0.000)	NA

[a] Significant values, at least at p < 0.05, are bolded and italicized.
[b] All cells include unstandardized coefficients, bootstrapping-based 95% bias-corrected confidence intervals for the coefficients, and two-sided p-values.
[c] For the logistic regression model, cells also include e^{β} and pseudo R (Nagelkerke R Square).

games are protective (decrease likelihood of gun-carrying) until this point, and pass this point, video gaming time is a small but statistically significant contributor to the odds of bringing a gun to school. Results also show that the odds of bringing a gun to school were decreased by 14.5% for every additional year in the 2012–2014 data; and by 15% for each increment in father's education, in the 2015–2017 data. The odds were increased more than five (four) fold for males compared to females in the 2012–2014 (2015–2017) data.

4. Discussion

The possible association between adolescent video gaming and aggressive behaviors has been elusive, and not agreed upon, with various studies and meta-analyses pointing to inconclusive results (Anderson, 2004; Anderson et al., 2010, 2017; Ferguson, 2007a, 2007b, 2015); some show positive but small association, and others show no association. This has led to healthy debates in various professional circles, including the US Surgeon General (US Surgeon General, 2001), the US supreme court, and the American Psychological Association. Here, I provide initial evidence that the observed inconsistencies in the association between video gaming and aggressive behavior found in prior research (Anderson et al., 2010; Anderson et al., 2017; Elson & Ferguson, 2014; Ferguson, 2007a; Ferguson, 2007b; Ferguson, 2015; Furuya-Kanamori; Doi, 2016; Hilgard; Engelhardt, & Rouder, 2017; Kepes, Bushman, & Anderson, 2017; Markey et al., 2015) can be attributed, in part, to the over-simplified perspective that consisted of a single theoretical account (typically the "imprinting through repeated exposure" perspective or more broadly the social learning perspective), and the resultant assumed linear association between (aggressive) video gaming time and problematic behaviors.

Specifically, the findings provide initial support for a U-shaped association between video gaming time and bringing a gun to school. They suggest dominance of the positive displacement hypothesis at low levels of video gaming time (from not playing video games to 2.1–2.8 h/day, based on our findings), which is overshadowed by the dominance of the "imprinting through repeated exposure" hypothesis at high levels of video gaming time (over 2.1–2.8 h/day, based on our findings). The findings also indicate higher prevalence rates of bringing guns to schools (about 1.5%) compared to findings in (Ybarra et al., 2014, p. 33% of 1.4% = 0.46%). While self-reported, these prevalence rates are still alarming and indicate that more research on this phenomenon is needed. I make the first strides toward understanding the role of video games in affording and/or promoting gun-carrying behaviors by adolescents.

4.1. Theoretical implications

The findings of the second block of the regression models (linear effect) were much like prior research on video gaming effects on violent behaviors – inconsistent. The 2012–2014 data provided support for this simplified/linear effect by showing a small but significant positive association between video gaming time and the frequency of bringing a gun to school. After accounting for control variables, each hour of video gaming increased the frequency of bringing a gun to school by 1.3%. However, this effect disappeared in the 2014–2017 data. In contrast, the U-shaped association was consistent across datasets. This illuminates the importance and strengthens confidence in the proposed bipartite theory of possible associations between video gaming and gun-related behaviors. Future research can extend this bipartite view of videogames to other technologies that may have protective sides, which, after a certain point, may be associated with problematic behaviors.

Another key contribution of this study is in pointing to an unexplored possible positive effect of video gaming on adolescents. The literature on the positive effects of video games on adolescents typically focused on developmental and brain-change benefits (Bavelier, Green, Pouget, & Schrater, 2012; Dye, Green, & Bavelier, 2009; Green & Bavelier, 2003, 2007). The literature on negative effects of video games on adolescents typically used the displacement hypothesis for suggesting that video gaming time detracts from the time devoted to other life domains (Gentile, Lynch, Linder, & Walsh, 2004), or used experiments to demonstrate that playing violent video games can impair anger recognition, increase self-perceived fighting ability and reduce perceptions regarding the toughness of opponents (Denson et al., 2019). The literature has also been more heavily slanted toward the adverse effects of video games (Ferguson, 2015). We show here that indeed video game use can be associated with undesirable adolescent behaviors, which is consistent with prior research (Anderson et al., 2008, 2010). However, we also show that at relatively low-medium levels of video gaming time, video games can actually have positive/protective effects on adolescents in terms of gun-related behaviors. Future research can examine the positive displacement hypothesis and the proposed bipartite perspective with other technologies.

Last, the observed sex differences are informative. The findings consistently show that males have elevated risk of bringing a gun to school, independent from other predictors. This is consistent with assertions claiming more aggressive behaviors, and especially physical ones among males (Björkqvist, 2018), and sex-differences in video gaming (Hartmann, Moller, & Krause, 2015; Jansz & Martens, 2005; Kuznekoff & Rose, 2013; Ribbens; Malliet, 2015; Williams, Martins, Consalvo, & Ivory, 2009). These findings imply that future research on associations between video gaming and aggressive behaviors should account for sex differences.

4.2. Practical implications

The findings suggest that low levels of video gaming may be encouraged by families and health professionals, especially for at-risk youth, as such activities can displace and reduce the potential for problematic behaviors. At the same time, I note that video gaming at higher levels should not necessarily be prevented (Shin & Huh, 2011), especially during unsucal times, such as epideomisc like COVID-19. Heavy use (presumably especially of violent games), however, may be considered a risk factor for gun-related behaviors (but not necessarily a strong predictor of such behaviors), especially for males. When such conditions exist, parents, teachers, and health professionals may want to monitor the situation more closely. Moreover, the findings suggest that legislators and governments should not necessarily try to restrict video gaming time or adolescent access to even violent video games (see one attempt described in Clements, 2012) because (1) general video gaming associations with gun-related behaviors are small, and (2) at low levels of general gaming time such activities can be useful and shelter adolescents from other, undesirable behaviors (Turel & Bechara, 2019). Similarly, the findings suggest that video game developers should be more mindful regarding possible adverse effects of gaming, but only after a certain threshold. Hence, suggestions made in prior research to include warning or game-lock mechanisms (Xu, Turel, & Yuan, 2012) can be efficacious and should take into account the transition point between the dominance of the displacement and imprinting forces. These implications, though, merit much more research given the observed small associations, the focus on general gaming time and not on violent games only, and the preliminary and correlational nature of our findings.

4.3. Limitations and future research directions

Ultimately, even though this study relied on two large datasets, findings of this study should be treated as preliminary, because our data were cross-sectional, restricted in scope (I was constrained by available national survey items, such as general gaming time) and self-reported, and focused on one specific problematic behavior. While the replication of the model in two datasets increase confidence in the bipartite theory, future longitudinal designs, with foci on a broader set of aggressive and/or problematic behaviors, separating violent and nonviolent games, and using objective data (e.g., video gaming logs), can be used for enriching and extending our findings and their generalizability. It would also be interesting to consider the effect of platforms in which shooting is more naturally simulated (e.g., Kinect) on gun-related behaviors in future research. In addition, I focused only on US adolescents (13–16 years old). Generalizability to other countries with different gun cultures and accessibility, as well as with varying responses to videogames and video gaming narratives (Ochoa et al., 2006; Welsh, 2016) should be established with data from additional countries. Moreover, the proposed model explained a small proportion of the variance in the target behavior. While this is understandable given the sparse and complex nature of the outcome variable (Glenn & Shelton, 1983; O'grady, 1982), and does not detract from the importance of studying such significant but small associations (Abelson, 1985), future research can include a broader range of predictors of gun-related behaviors. In addition, our study was constrained by available data to focus on all games and consequently did not account for the specific games and/or types of games adolescents play. Although I show that the most popular games among adolescents include many violent features, it would be interesting to consider if our model improves when the focus is only on violent games and/or level of violence in games is directly included in the model. The model can also be extended to focus on competition within games, frustration, and not just violence, as competition and frustration are more potent drivers of aggressive affect than violence itself (Dowsett & Jackson, 2019). This also means that the recommendations regarding desirable and risky gaming time should be taken with caution, and be fine-tuned to account for the type of games adolescents play an special cirumstances (like COVID-19).

5. Conclusion

Overall, video games are a staple of modern life. Yet, they have been blamed for, perhaps unjustifiably, many aggressive adolescent behaviors. This study presents a more balanced view through a theory that accounts for both positive and negative associations between video-games and problematic adolescent behaviors. The findings provide initial support to the idea that low levels of general video gaming can be protective. In contrast, higher levels of general video gaming time can be a small risk factor for gun-related behaviors. These findings show that the moral panic over video games in general, many of which include aggressive elements, is largely unsubstantiated, but also that there may be some kernel of truth in attributing some (small) blame to video games, but only at very high levels of use. I call for further testing our theory and for adjusting public statements portraying video games as primarily negative.

Data Availability Statement: The data that support the findings of this study are available from the Inter-university Consortium for Political and Social Research (ICPSR) by request (see https://www.icpsr.umich.edu/icpsrweb/ICPSR/series/35), but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are, however, available from the authors upon reasonable request and with permission of the Inter-university Consortium for Political and Social Research (ICPSR).

Competing interests: The authors declare no competing interests. **Role of** Funding **Source:** Nothing declared.

Contributors: OT initiated the study, analyzed the data, wrote and edited the manuscript, and approved the final submission.

Declaration of competing interest

There are no conflicts of interest to be declared.

CRediT authorship contribution statement

Ofir Turel: Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing - original draft, Writing - review & editing.

Acknowledgements

None Study procedures have been approved by the Institutional Review Board of the University of Michigan and meet common ethical guidelines. **Data Availability Statement:** The data that support the findings of this study are available from the Inter-university Consortium for Political and Social Research (ICPSR) by request (see https://www.icpsr.umich.edu/icpsrweb/ICPSR/series/35), but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of Inter-university Consortium for Political and Social Research (ICPSR).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.chb.2020.106355.

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