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A Longitudinal Study of Risk-Glorifying Video Games and Reckless Driving

Jay G. Hull and Ana M. Draghici
Dartmouth College

James D. Sargent
The Geisel School of Medicine at Dartmouth

A multiwave longitudinal study investigated the association of playing mature-rated and risk-glorifying video games and risky driving among adolescents. The study involved a large random digit dial telephone survey. Data were analyzed using structural equation modeling and included auto-regressive lags for the major outcome variables. Consistent with predictions, playing the targeted games was associated with increased reports of a variety of risky driving habits (e.g., speeding, tailgating, weaving in traffic), being pulled over by the police, automobile accidents, and willingness to drink and drive. These effects were observed after controlling for a variety of demographic and parenting variables. Finally, the effects of these games were shown to be mediated by increases in sensation seeking and rebelliousness. The results support a view of video games as affecting real-world behavior by altering a sense of self.

Keywords: video games, reckless driving, automobile accidents

Research on the adverse effects of video games has focused primarily on violent games and aggressiveness. A large body of research has shown that playing violent video games increases aggressiveness in laboratory-based experimental studies (Anderson et al., 2010). In addition, longitudinal studies show that play of violent games is associated with increased aggressiveness over time (Anderson, Gentile, & Buckley, 2007), although the effect sizes are generally small. Recently, research on video gameplay has begun to investigate behaviors other than aggression. The current study examines the association of playing mature-rated and risk-glorifying video games with reckless driving by adolescents.

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Jay G. Hull and Ana M. Draghici, Department of Psychological and Brain Sciences, Dartmouth College; James D. Sargent, Norris Cotton Cancer Center, The Geisel School of Medicine at Dartmouth.

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Correspondence concerning this article should be addressed to Jay G. Hull, Department of Psychological and Brain Sciences, Dartmouth College, Hanover, NH 03755. E-mail: jay.hull@dartmouth.edu

Empirical Literature

Cross-Sectional Studies

Two recent cross-sectional studies have reported that self-reported video gameplay is correlated with reports of risky driving habits. Fischer, Kubitzki, Guter, and Frey (Study 1, 2007) found that frequently playing racing video games was positively correlated with self-reported competitive driving and car accidents and negatively correlated with cautious driving. Similarly, Beullens, Roe, and Van den Bulck (2008) found that playing racing games was correlated with the intention to engage in risky driving.

Experimental Studies

Several experimental studies have been conducted in which participants are randomly assigned to play either a racing or a nonracing video game. These studies support the hypothesis that racing gameplay increases risky driving-related behaviors. In two experiments, Fischer et al. (2007) found that relative to playing a control game, playing racing games increased accessibility of risk-taking cognitions and taking greater risks in computer-simulated road traffic situations. Similarly, Fischer et al.

(2009) found that playing racing games increased risk-promoting cognitions as well as general sensation seeking. Furthermore, the effect of playing such games on risk taking in simulated road conditions was found to be partially mediated by changes in perceptions of self as a reckless driver. These effects were only observed when the game rewarded traffic violations and when the individual was an active player rather than a passive observer.

Longitudinal Studies

Although correlational and laboratory simulator studies support an association of video gameplay and risky driving, the only longitudinal evidence that video gameplay is associated with risky driving behavior comes from a recent study by Beullens, Roe, and Van den Bulck (2011). A follow-up to the correlational study by Beullens et al. (2008); Beullens et al. (2011) found that racing video gameplay was related to risky driving attitudes and intentions, which in turn were associated with two self-reported risky driving behaviors (fun riding and speeding; although not drinking and driving) in a two-wave panel design.

Although an important first step, the Beullens et al. (2011) study is limited in several respects. Of greatest relevance, they did not provide evidence that Wave 1 video gameplay was significantly related to Wave 2 measures of driving behavior. Instead they showed that video gameplay was related to driving attitudes and intentions within Wave 1 (see Beullens et al., 2008 for an earlier model of these effects) and that Wave 1 intentions toward risky driving were predictive of Wave 2 risky driving. Stronger evidence of mediation is provided if one can establish that there is a direct effect to be mediated (see Baron & Kenny, 1986). In addition, Beullens et al. (2011) did not control for key background variables such as parental education, income, or parenting style. Finally, they provided a limited assessment of risky driving behaviors that did not include serious infractions such as police stops and automobile accidents. The present study seeks to address such issues by providing a more rigorous test of mediation, controlling for a variety of background covariates (including demographics and parenting style), and assessing multiple forms of risky driving.

Theoretical Perspectives

As should be apparent from this brief review, the literature on video gameplay and reckless driving is small and limited to particular types of video gameplay (racing games). The focus of research on racing games follows from an implicit conceptualization of video games as behavioral simulators. From this perspective, individuals learn to act in particular ways in the virtual environment of the game. Behavioral scripts rewarded in the game then serve to guide behavior in the real world. Racing games are argued to increase recklessness because they entrain bad driving habits (e.g., speeding, tailgating, weaving through traffic) as a means of obtaining short-term rewards (game points) with very little cost (virtual accidents). The research by Beullens et al. (2011) typifies this approach insofar as gameplay and risky driving behaviors are proposed to be associated only for ". . . risky driving acts which frequently occur in video games, that is, speeding and fun riding" (p. 64) and not for acts that do not frequently occur in video games (e.g., drinking and driving).

This *behavioral simulation* logic is distinct from one in which video games affect general personality characteristics and self-perceptions (e.g., Uhlmann & Swanson, 2004). According to the latter perspective, video games serve as opportunities to try out different selves with implications that go beyond the actual behaviors simulated in the game. The logic of the research by Fischer et al. (2009) and Fischer, Kastenmüller, and Greitemeyer (2010) typifies this *identity simulation* approach insofar as self-perception as a reckless driver is hypothesized to mediate the effect of video gameplay on reckless driving. Fischer et al. (2009) adopt the ". . . main assumption . . . that racing games make players more comfortable with breaking traffic rules, which carries over to the risk taking in real driving situations" (p. 1397) and demonstrate that playing racing video games increases generalized sensation seeking and not simply driving-related cognitions and behaviors. Although the Fischer et al. studies use racing video games, the self-perceptions theorized to mediate the observed effects ("I am behaving recklessly because I *am* a reckless person"; Fischer et al., 2009, emphasis in original, p. 1398) neither require video game effects

to be limited to driving games (they can follow from other nondriving games that encourage self-perceptions of recklessness), nor are the effects of driving video games necessarily restricted to driving outcomes (they can affect a broad variety of behaviors typical of "recklessness"). A recent meta-analysis supports this view of the impact of risk-glorifying media exposure on risk cognition, emotion, and behavior (Fischer, Greitemeyer, Kastenmüller, Vogrincic, & Sauer, 2011).

Current Study

Consistent with the "identity simulation" logic that video gameplay affects behavior by altering self-perceptions, we hypothesized that gameplay increases subsequent risky driving because of its effects on risk-related self-perceptions of sensation seeking and rebelliousness. Specifically, we hypothesized that (1) Playing mature-rated and risk-glorifying video games will be associated with subsequent increases in sensation seeking, rebelliousness, and self-reported risky driving behaviors; and (2) The effect of gameplay on driving behaviors will be at least partially mediated through increases in sensation seeking and rebelliousness. These hypotheses were tested using structural equation modeling applied to a longitudinal data set with four measurement periods or "waves." The principal outcome variables of interest were self-reports of risky driving habits (e.g., speeding, tailgating, running stop signs, etc.), police stops, automobile accidents, and willingness to drink and drive. Insofar as gameplay is proposed to have its effects on driving by increasing sensation seeking and rebelliousness rather than by entraining specific virtual driving habits, in testing these predictions we did not restrict ourselves to racing video games but rather assessed play of mature-rated games and risk-glorifying driving-related (*Grand Theft Auto*) and non–driving-related games (*Manhunt*, *Spiderman*). Finally, we predicted that these effects would remain after controlling for demographic (gender, age, race, parental income, parental education) and parenting (responsiveness, demandingness) variables.

Methods

Participants

We conducted a multiwave random-digit-dial (RDD) telephone survey of US adolescents. The aim of the survey was to assess media exposures and adolescent risk behaviors. The survey contained, among other variables, questions about video game use, driving behaviors, and personality constructs. To recruit the sample, we first generated a random sample of residential phone numbers, identified households with age-eligible adolescents, obtained permission from the parents to interview their child, and enrolled the adolescents to participate in the study. Our response rate (which includes estimates of households lost during the screening process) of 32% is typical for a contemporary RDD survey with two levels of consent needed to complete an interview. The characteristics of the families mirrored the results for the 2000 U.S. census with respect to age, gender, region of the country, and household income. The initial sample was 49% female. Distribution by race/ethnicity was 11% African American, 2% Asian/Pacific Islander, 62% Caucasian, 19% Hispanic, 0.4% Native American/Alaska Native, 6% multiple ethnicity, and 0.3% other ethnicity.

Measures

Video game measures. At Wave 0, participants were asked "How often do your parents let you play mature-rated video games" on a 4-point scale: *"Never, once in a while, sometimes, all the time."* A fifth response allowed participants to report that they did not play video games. Unless participants reported that they did not play video games, they were then asked whether or not they had played three specific games: *Spiderman II*, *Grand Theft Auto III* (*GTA*), and *Manhunt*. All three of the latter games are violent and risk glorifying in content although they vary in the extremity of violence allowed and the depiction of gore. In addition, *GTA* specifically encourages reckless driving. A composite 4-item video game measure was created among participants who acknowledged that they did play video games by standardizing and summing these measures (Wave 0, $\alpha = .56$).

Personality measures. Measures of individual differences in sensation seeking and rebelliousness were collected at both Waves 0 and

1. Sensation seeking was measured by four items: "I like to do scary thinks"; "I like to do dangerous things"; "I often think that there is nothing to do"; "I like to listen to loud music." Each item involved a 4-point scale: *"Would you say it's not like you, a little like you, a lot like you, or just like you?"* These items were then summed to form a scale (Wave 0, $\alpha = .62$; Wave 1, $\alpha = .62$) that has been extensively validated (Sargent, Tanski, Stoolmiller, & Hanewinkel, 2010) and shown to predict a variety of outcomes among adolescents (Stoolmiller, Gerrard, Sargent, Worth, & Gibbons, 2010; Wills et al., 2010).

Rebelliousness was measured by four items: "I get in trouble at school"; "I argue a lot with other kids"; "I argue with teachers"; "I like to break the rules" using the same response choices as for Sensation Seeking. These items were summed to form a scale (Wave 0, $\alpha = .74$; Wave 1, $\alpha = .76$).

Driving measures. At both Waves 2 and 3, participants were asked whether they had been pulled over by the police (*Yes/No*) and whether they had been in an automobile accident during the preceding year (*Yes/No*). Drivers were also asked whether they engaged in unsafe driving practices including nine questions about specific aspects of reckless driving ("Have you ever driven in the following ways: Speed? Tailgate? Fail to yield? Weave in and out of traffic? Run one or more red lights? Ignore stop signs? Pass on a double yellow line? Speed through a yellow light? Drive without your seatbelt fastened?"). All items involved a dichotomous scale (*Yes/No*) and were drawn from The National Survey of Speeding and Other Unsafe Driving Actions (*http://www.nhtsa.gov/people/*injury/aggressive/unsafe/), conducted by the National Traffic Safety Administration in 1998 (*http://www.nhtsa.gov/people/injury/aggressive/unsafe/methods/* QxUDA.html). At Wave 2, these nine questions were asked only among participants who had admitted that they "had engaged in unsafe driving habits." Participants who claimed that they had not engaged in unsafe driving habits were coded *"No"* to all of the individual unsafe practices (Wave 2, $\alpha = .84$). At Wave 3, the nine specific unsafe practices were asked of all participants without including the unsafe driving habit screening question (Wave 3, $\alpha = .66$).

Finally, all participants were asked two questions regarding drinking and driving: "Now suppose you and your friends have each had more than 3 drinks and it's time to go home. Each of you has a license to drive. How willing would you be to drive yourself home?" (*Not at all willing, kind of willing, very willing*)" and "How willing would you be to get a ride from a friend who was drinking?" (same scale). These items were summed to create a single scale (Wave 2, $\alpha = .43$; Wave 3, $\alpha = .43$).

Background covariates. The principal analyses controlled for participants' age (in months), gender, race (white/nonwhite), parental income, and parental education. In addition, they controlled for two parenting variables: warmth/responsiveness and demandingness using a modified version of an authoritative measure validated by Jackson and colleagues (Jackson, Bee-Gates, & Henriksen, 1994; Jackson, Henriksen, & Foshee, 1998). Parental warmth and responsiveness was measured by five items that referred to the adult with whom they spent the most time in an average week (e.g., she/he "listens to what I have to say"; "makes me feel better when I'm upset"; "likes me just the way I am"). Each item involved a 4-point scale: *"Would you say that's not like, a little like, a lot like, or just like him/her?"* These items were then summed to form a scale (Wave 0, $\alpha = .82$). Parental demandingness was measured by four items (e.g., she/he "knows where I am after school"; "makes sure I go to bed on time"; "asks me what I do with my friends"). These items were then summed to form a scale using the same four responses as for parental warmth and responsiveness (Wave 0, $\alpha = .67$).

Procedures

For the purposes of this report, the first survey in which questions about mature-rated video game play were included is designated as Wave 0. An interval of 8 months separated this survey and the next survey, designated Wave 1. One and one half years separated Wave 1 and Wave 2. Two years separated Waves 2 and 3. The sample of interviewed adolescents at each wave was 5019 (Wave 0), 4575 (Wave 1), 3653 (Wave 2), and 2718 (Wave 3). The average age of participants at each of the respective waves was 13.8, 14.5, 15.9, and 17.9 years. As is typical of longitudinal surveys of this nature,

adolescents lost to follow-up were more likely to be minorities (Black, Hispanic, or other), and be from families with lower parental education and income. In addition, they had lower school performance, and were higher on sensation seeking, rebelliousness, and video game play.

The telephone surveys were conducted by trained interviewers who administered the survey in English or Spanish using a computer-assisted telephone interview (CATI) system. To protect confidentiality, adolescents indicated their answers to sensitive questions by pressing numbers on the telephone, rather than speaking aloud. Respondents were paid $5.00 for completing each interview. All aspects of the survey were approved by two institutional review boards (Committee for the Protection of Human Subjects at Dartmouth College, and the Human Subjects Committee at Westat, the survey contractor).

Results

Gameplay Descriptive Statistics

In our sample, 35.5% of participants reported that they did not play video games, 15% reported that their parents never allowed them to play mature-rated games, and the remaining 49.5% of participants reported that their parents allowed them to play mature-rated games at least occasionally. Among those participants who reported that they did play video games, 32.4% reported that they had played *Spiderman II*, 12.3% *Manhunt*, and 57.9% *Grand Theft Auto III*.

Driving Descriptive Statistics

In our sample, 11.3% of participants admitted to being pulled over by the police at Wave 2. This figure had increased to 21.0% by Wave 3. With respect to accidents, 7.8% of participants at Wave 2 and 14.0% of participants at Wave 3 admitted to having been in an accident while driving. At both Wave 2 and Wave 3, one-quarter of participants said that they were at least somewhat willing either to drive themselves after consuming more than three alcoholic drinks or ride with a friend who had drunk a similar amount (24.9% and 25.5%, respectively).

At Wave 2, participants were asked if they engaged in any unsafe driving habits, to which 25.2% of participants responded "Yes" and were asked about nine specific habits. At Wave 3, the screening question was dropped in favor of simply asking about the nine specific habits. At this wave, 90.4% of participants responded "Yes" to at least one of the nine risky habits (speeding: 78.1%; tailgating: 26.1%; failure to yield: 22.6%; weaving in and out of traffic: 25.3%; running red lights: 20.1%; ignoring stop signs: 18.6%; passing across a double yellow line: 12.5%; speeding through yellow lights: 71.0%; not fastening one's seatbelt: 27.2%).[1]

Correlation Matrices

A zero-order correlation matrix for the variables of primary interest appears in Table 1, along with means and standard deviations for the Video Game composite scale (Wave 0), Sensation Seeking (Waves 0 and 1), Rebelliousness (Waves 0 and 1), reports of having been pulled over by the police during the past year (Waves 2 and 3), reports of having been in an automobile accident during the past year (Waves 2 and 3), the Risky Driving composite scale (Waves 2 and 3), and reports of willingness to drink and drive (Waves 2 and 3). All correlations in excess of $r = .064$ are statistically significant. As can be seen, this includes all but 10 of the 78 correlations. Of note, video gameplay is significantly related to all of the other variables in the matrix.

A partial correlation matrix appears in Table 2, along with adjusted means and standard deviations for all of the variables in Table 1 after covarying the control variables of Age, Gender, Race (white/nonwhite), Parental Education, Parental Income, Parental Responsiveness, and Parental Demandingness. As can be seen, all but 16 of 78 correlations are significant after taking into account the control variables, including all but 2 of the associations involving gameplay. Of note, gameplay remains significantly related to all of the driving variables assessed at Wave 3.

Structural Equation Models

Residualized matrix. For the purpose of modeling direct and indirect associations of video gameplay and driving behavior, structural

[1] Although we did not assess whether participants had a drivers license at Waves 2 or 3, it is apparent from their responses that the vast majority were driving at Wave 3.

Table 1
Zero-Order Correlations

	VGP 0	SS0	Rebel0	SS1	Rebel1	PO2	AA2	RD2	DD2	PO3	AA3	RD3	DD3
Videogame play 0	1.000												
Sensation seek 0	.368	1.000											
Rebelliousness 0	.276	.521	1.000										
Sensation seek 1	.331	.727	.421	1.000									
Rebelliousness 1	.240	.432	.696	.484	1.000								
Pulled over 2	.171	.126	.065	.121	.050	1.000							
Auto accident 2	.070	.119	.034	.086	.042	.241	1.000						
Risky driving 2	.184	.262	.169	.245	.183	.302	.157	1.000					
Drink and drive 2	.127	.178	.178	.160	.178	.060	−.014	.183	1.000				
Pulled over 3	.165	.161	.142	.160	.125	.260	.169	.224	.081	1.000			
Auto accident 3	.104	.060	.089	.056	.106	.071	.122	.052	.039	.227	1.000		
Risky driving 3	.192	.227	.146	.229	.150	.168	.145	.377	.119	.341	.158	1.000	
Drink and drive 3	.175	.181	.184	.213	.184	.066	.072	.202	.298	.135	.020	.241	1.000
Means	.412	8.486	5.680	8.678	5.769	.118	.076	.966	2.373	.251	.147	3.244	2.447
Standard deviations	2.463	2.515	1.954	2.508	1.997	.323	.265	1.817	.719	.434	.355	1.974	.808

Note. VGP = videogame play; SS = sensation seeking; Rebel = rebelliousness; PO = pulled over; AA = automobile accident; RD = risky driving; DD = willingness to drink and drive. All correlations > .064 significant at $p < .05$, two-tailed. $N = 1018$.

equation models were applied to the matrix in Table 2 using EQS (Bentler, 1995).

Direct effects model. Consistent with Hypothesis 1, an initial direct effects model was specified in which video gameplay was used to predict personality variables and driving behaviors over the course of four waves of time. All theorized effects appear as arrows in Figure 1. At Wave 0, Gameplay was allowed to correlate with the personality variables of Sensation Seeking and Rebelliousness. Gameplay at Wave 0 was then used to predict (a) Wave 1 Sensation Seeking and Rebelliousness, controlling for their respective Wave 0 auto-regressive lags, (b) Wave 2 driving self-reports of being stopped by the police, automobile accidents, risky driving behaviors, and willingness to drive after consuming alcohol, and (c) Wave 3 driving self-reports, controlling for

Table 2
Partial Correlations

	VGP 0	SS0	Rebel0	SS1	Rebel1	PO2	AA2	RD2	DD2	PO3	AA3	RD3	DD3
Videogame play 0	1.000												
Sensation seek 0	.310	1.000											
Rebelliousness 0	.179	.425	1.000										
Sensation seek 1	.264	.688	.321	1.000									
Rebelliousness 1	.166	.350	.639	.412	1.000								
Pulled over 2	.073	.074	.024	.071	.013	1.000							
Auto accident 2	.037	.096	.011	.063	.038	.188	1.000						
Risky driving 2	.076	.220	.132	.212	.168	.195	.104	1.000					
Drink and drive 2	.043	.107	.081	.102	.116	.032	−.021	.156	1.000				
Pulled over 3	.098	.109	.083	.123	.066	.191	.141	.152	.065	1.000			
Auto accident 3	.072	.041	.066	.044	.094	.036	.102	.013	.013	.209	1.000		
Risky driving 3	.122	.195	.102	.211	.127	.096	.117	.303	.110	.306	.141	1.000	
Drink and drive 3	.117	.151	.117	.178	.146	.038	.069	.173	.284	.133	.011	.227	1.000
Means	.407	8.470	5.684	8.657	5.766	.117	.077	.948	2.365	.253	.145	3.234	2.446
Standard deviations	2.451	2.500	1.941	2.498	1.987	.322	.267	1.800	.709	.435	.353	1.956	.805

Note. VGP = videogame play; SS = sensation seeking; Rebel = rebelliousness; PO = pulled over; AA = automobile accident; RD = risky driving; DD = willingness to drink and drive. All correlations > .064 significant at $p < .05$, two-tailed. $N = 947$. Partial correlations controlling for Age, Gender, Race, Parental Education, Parental Income, Parental Responsiveness, Parental Demandingness.

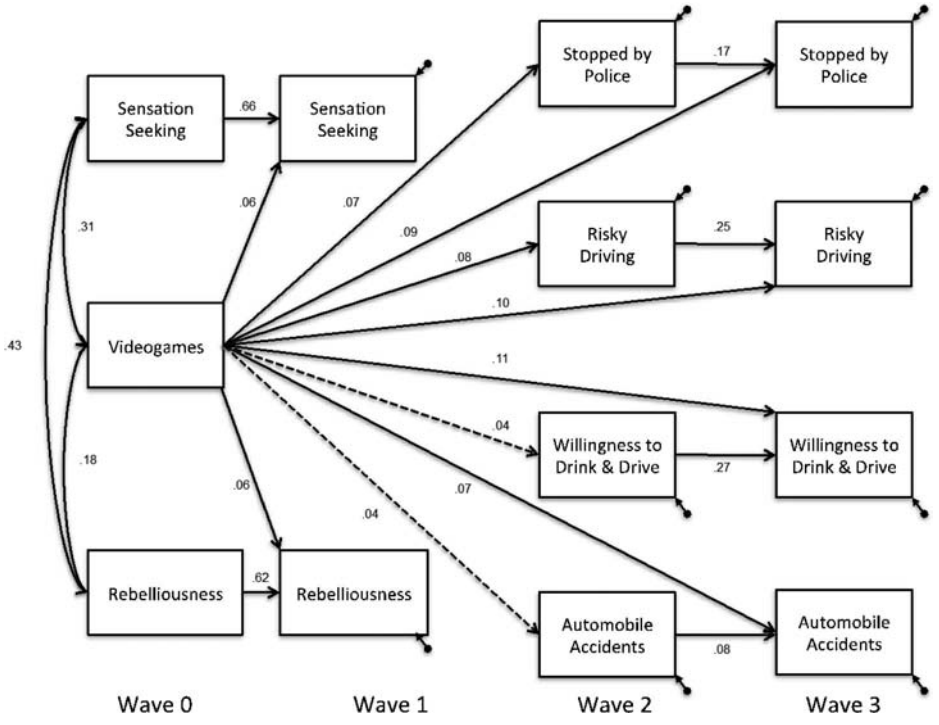


Figure 1. Direct effects model.

their respective Wave 2 autoregressive lags. Error variances were allowed to correlate within each wave.

This initial direct effects model provided a good fit to the data, $\chi^2(46, N = 947) = 169.03$, $p < .001$, CFI = .94, SRMR = .067, RMSEA = .053, $.045 < \varepsilon < .062$.[2] Of the 10 hypothesized direct effects of Video Gameplay on personality and driving, 8 achieved statistical significance. This model is depicted in Figure 1 (nonsignificant paths are dotted).

Mediational model. Consistent with Hypotheses 2 and 3, a mediational model was specified in which video gameplay was predicted to affect driving behavior in part because of its effects on increasing Sensation Seeking and Rebelliousness. In addition, it was hypothesized that to the extent that these variables affect risky driving habits, participants would be more likely subsequently to report being stopped by the police, being in an automobile accident, and an increased willingness to drink and drive. To test this mediational model, the initial direct effects model was modified to include (a) direct effects of Wave 1 Sensation Seeking and Rebelliousness on all Wave 2 and Wave 3 driving variables, and (b) direct effects of Wave 2 risky driving habits on all Wave 3 driving variables.

This mediational model provided an excellent fit of the data, $\chi^2(27, N = 947) = 48.74$, $p < .01$, CFI = .99, SRMR = .024, RMSEA = .029, $.015 < \varepsilon < .042$. This model is depicted in Figure 2 after trimming all nonsignificant paths. This trimmed model also provided an excellent fit of the data, $\chi^2(47, N = 947) = 74.62$, $p < .01$, CFI = .99, SRMR = .037, RMSEA = .025, $.013 < \varepsilon < .035$. According to this model, video gameplay affects risky driving habits, automobile accidents, being stopped by the police (Wave 3), and a willingness to drink and drive because it is associated with an increase in general rebelliousness and sensation seeking.

[2] CFI (Comparative Fit Index); SRMR (Standardized Root Mean Residual); RMSEA (Root Mean Square Error of Approximation); ε (RMSEA parameter).

Thus, with one exception, all of the direct effects of video gameplay are replaced with indirect effects through personality. Of the personality variables, both appear to provide unique predictive utility.[3,4]

Discussion

Across multiple waves of data, playing video games was associated with self-reports of risky driving after controlling for a variety of demographics and prior measures of risky driving. Specifically, video game play was associated with reports of automobile accidents, being stopped by police, and a variety of unsafe driving habits including speeding, tailgating, weaving, and crossing over a double yellow line. It was also associated with an attitudinal expression of a willingness to drink and drive. An initial model revealed direct effects of video game play on all of these variables after controlling for background covariates and autoregressive effects. A subsequent model supported the hypothesis that these effects are mediated through the effects of video game play on sensation seeking and rebelliousness. These findings are consistent with the notion that games do more than entrain specific behavioral scripts integral to the particular type of game (e.g., racing games $\rightarrow$ risky driving habits); mature-rated and risk-glorifying games can also result in personality development consistent with the risk-taking, rebellious characters enacted in a game. In this way, they may have broader behavioral consequences that apply to other risky behaviors. For example, future research might investigate whether increases in sensation seeking and rebelliousness may also mediate increases in drinking, smoking, and other risky behaviors.

Limitations

Despite strengths of the current design (its size, random sampling procedures, covariate controls, and multiwave longitudinal nature), the current study is also limited in several respects. Most notably, although a longitudinal design is superior in several respects to cross-sectional designs, it is not an experimental design and hence causal interpretations remain speculative. At the same time, it should be noted that the study begins with participants who are (a) playing videogames, but (b) at an age in which they are unlikely to be driving extensively, if at all. We feel that this is a strength of our design, because it makes it abundantly clear that the videogame exposure preceded the risky driving. Specifically, if participants are not driving when we measure their video game play, then an interpretation based on reverse causality is simply not possible.

A second limitation concerns the fact that these effects of gaming are based on an adolescent sample that may be more malleable in their self-perceptions than adults. Third, although rates of attrition were typical for this type of design and subsidiary analyses suggested that parameter estimates were not biased by differential attrition (see footnote 4), one can never unequivocally state that attrition had no effects on the results. Finally, all variables in the current study involve self-reports, and although objective measures of gameplay and reckless driving are difficult to obtain, future research based on such measures is warranted.

[3] The data were also modeled using (a) a video game latent variable with all four gameplay items as indicators, and (b) a 2-item scale consisting of just the mature-rated gameplay and GTA items ($\alpha = .70$). In both cases, the structural paths for the models remained virtually identical to those depicted in the figures.

[4] Given that modeling was restricted to participants with complete data, subsidiary analyses were conducted to assess potential bias introduced by differential attrition on variables included in the model. As noted, compared with participants without complete data, participants with complete data were lower in sensation seeking and rebelliousness, and lower on the measure of playing mature-rated videogames. There were no differences on the driving measures of being pulled over by the police, being in automobile accidents, or engaging in risky driving habits, but participants with complete data did report being less willing to drink and drive. All these effects were very small, accounting for $< 1\%$ of variance. To address potential attrition bias, we examined whether the association of one predictor with an outcome varied as a consequence of the level of another predictor (a statistical interaction), such that selection based on the second predictor biased the observed association of the first predictor with the outcome. We tested for 30 possible interactions involving videogame play (3 interactions = sensation seeking by gameplay, rebelliousness by gameplay, and sensation seeking by rebelliousness by gameplay $\times$ 10 outcome variables = 30 tests). Only two of these interactions achieved statistical significance, a finding consistent with chance. Based on these analyses, we suggest that attrition bias probably does not affect the results reported in this study.

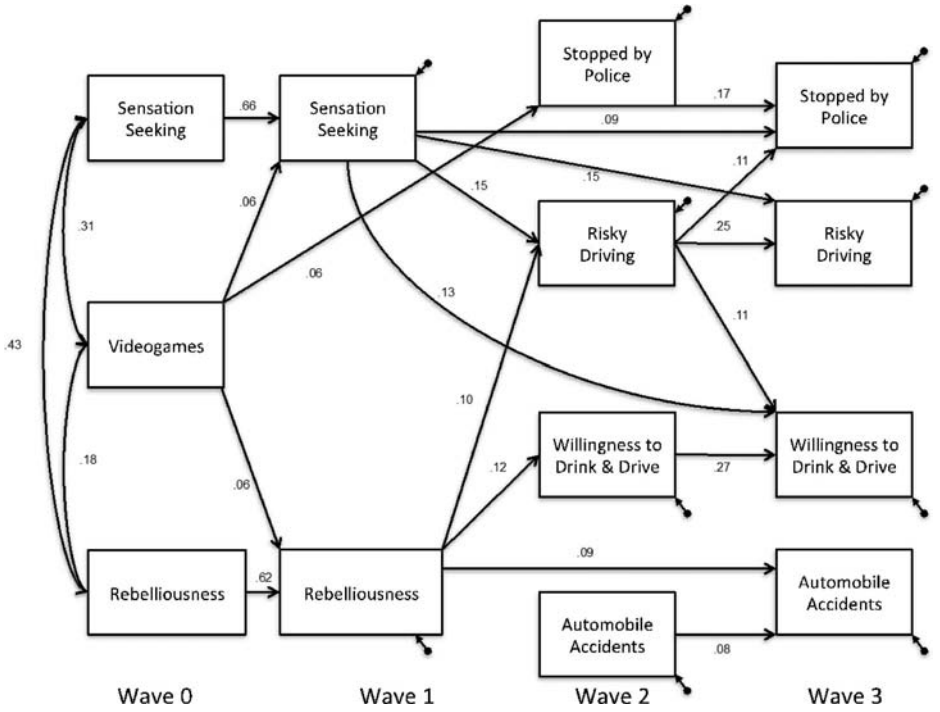


Figure 2. Trimmed mediational model.

Conclusion

Because video games are extremely popular (half of all respondents reporting that they play mature-rated games at least occasionally and a third reporting having played the specific game of *Grand Theft Auto III*), even small individual effect sizes can have important implications at the population level. Moreover, the effects observed in the present study (a) persisted after covarying a variety of background variables such as gender and parenting style and (b) were similar or larger than other known associates of reckless driving. For example, most parents would probably be disturbed to learn that in supplemental analyses we observed that game play was more predictive of being pulled over by the police than their parenting practices. Similarly, insurance companies might be interested to learn that accidents were more strongly related to game play than gender. Insofar as the number one cause of adolescent deaths is motor vehicle accidents (Shope & Bingham, 2008), the ultimate consequences of popular games that increase reckless driving may constitute even more of a public health issue than the widely touted association of video games and aggression. More work is needed to understand how game playing behaviors might lead to higher risk taking generally, but the present study provides key evidence about this association in the domain of driving.

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