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Video Game Playing, Attention Problems, and Impulsiveness: Evidence of Bidirectional Causality

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The present study examines video game playing as it relates to attention problems and impulsiveness in a sample of 3,034 children and adolescents from Singapore measured over 3 years. Consistent with previous research, those who spend more time playing video games subsequently have more attention problems, even when earlier attention problems, sex, age, race, and socioeconomic status are statistically controlled. Violent content may have a unique effect on attention problems and impulsiveness, but total time spent with video games appears to be a more consistent predictor. Individuals who are more impulsive or have more attention problems subsequently spend more time playing video games, even when initial video game playing is statistically controlled, suggesting bidirectional causality between video game playing and attention problems/impulsiveness.

Keywords: video games, attention problems, impulsiveness, media effects, bidirectionality

Problems associated with attention disorders, such as attention deficit hyperactivity disorder (ADHD), impair a variety of functions, particularly school performance (Barry, Lyman, & Klinger, 2002). Attention disorders are substantially biologically based, but have environmental risk factors as well (Biederman et al., 2008). Some recent evidence suggests that exposure to screen media may increase attention problems (e.g., Christakis, Zimmerman, DiGiuseppe, & McCarty, 2004; Landhuis, Poulton, Welch, & Hancox, 2007; Swing, Gentile, Anderson, & Walsh, 2010). Most of the research to date has focused on television (TV) as a potential contributor to attention problems (e.g., Acevedo–Polakovich, Lorch, & Milich, 2007; Christakis et al., 2004; Johnson, Cohen, Kasen, & Brook, 2007; Landhuis et al., 2007; Mistry, Minkovitz, Strobino, & Borzekowski, 2007; Zimmerman & Christakis, 2007). Research examining video games has found similar associations with attention problems, though more research examining video games would be useful (Bioulac, Arfi, & Bouvard, 2008; Chan & Rabinowitz, 2006; Swing et al., 2010). A few studies have found mixed results (Ferguson, 2010) or no evidence of media effects (Obel et al., 2004; Stevens & Mulsow, 2006) on attention problems. However, these studies either also found significant bivariate correlations between electronic media and attention problems or did not report such analyses.[1] Fn1

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[1] It should also be noted that other research has found playing action video games to lead to improvements in measures of visual attention (e.g., Green & Bavalier, 2003). Though the word "attention" is used in both areas of research, it actually refers to different abilities. Specifically, attention problems refers to difficulties in engaging in or sustaining adaptive, goal oriented behavior or mental processes, particularly in difficult, effortful, or boring contexts. Visual attention, on the other hand, refers to the rapid and accurate extraction from the environment and processing of visual information. It is thus possible that electronic media use impairs the former ability while improving the latter.

There are at least four possible explanations for the association between electronic media and greater attention problems.

Excitement hypothesis. Electronic screen media may make other activities (e.g., work or school) seem less interesting by comparison. Many TV shows and video games are very exciting and fun, and they include potent attention grabbing cues (e.g., violence). Indeed, most shows and video games (especially violent ones) make liberal use of features that trigger an orienting response, such as edits, sound effects, flickering light levels, and so forth (Kubey & Csikszentmihalyi, 2002). These salient features provide a type of continual support for attention. This is quite different from many of the work and school tasks that are difficult for those with attention problems. Over time, frequently engaging in exciting activities (e.g., playing video games) might change a child's expectations regarding the desired level of stimulation. The greater the contrast between electronic media content and work or school tasks, the more difficult it could become to focus on work or school.

Displacement hypothesis. Second, time spent with TV or video games might simply displace time that would have otherwise been spent on other activities that would have allowed for greater development of impulse control. These two explanations need not be mutually exclusive. Both are consistent with the strength model of self-control[2] (Baumeister, Vohs, & Tice, 2007). Specifically, to the extent that electronic media use does not tax self-control resources, time spent with such media may weaken ones' ability to exert self-control. The excitement and displacement hypotheses would be consistent with different associations between electronic media variables and attention problems. If attention problems are simply the result of the displacement of self-control building activities, total time spent with electronic media should predict greater attention problems but the content of that media should not make a difference. If the contrast between exciting TV or video games and work or school tasks is important, then differences in content (e.g., greater violence) should predict greater attention problems in addition to or instead of total media exposure. There have been few tests of this possibility. Zimmerman and Christakis (2007) found violent TV to be most strongly related to attention problems (followed by nonviolent TV and then educational TV); however, the difference between violent and nonviolent TV content was not statistically significant.

Attraction hypothesis. A third possibility is that individuals who have attention problems are more attracted to electronic media. This explanation need not be mutually exclusive with the first two explanations of a causal effect of electronic media on attention problems. In fact, it is consistent with the strength model of self-control that exciting electronic media that do not require self-control would be frequently used by those with lower ability to exert self-control (Baumeister et al., 2007). Those with lower self-control may find the appeal of exciting electronic media too difficult to resist. To date, this hypothesis has not been tested using longitudinal data.

Third variable hypothesis. A fourth possibility is that the observed association between electronic media and attention problems is spurious. A third variable such as sex may explain this association. Thus far, evidence for third variable explanations is weak. For example, several studies (e.g., Christakis et al., 2004; Swing et al., 2010) included sex, age, and other individual difference variables as covariates and still found unique associations between electronic media and attention problems. Ferguson (2010) reported a regression model in which the electronic media effects are nonsignificant, but this model included four highly correlated electronic media variables entered separately (reducing the variance of each media predictor by approximately 25–50% due to covariates that are not alternative explanations). The model also included 12 other covariates, some of which do not seem to be plausible alternative causal explanations (e.g., antisocial personality). No model was presented involving only the theoretically relevant covariates, leaving a very strong possibility that the inclusion of improper covariates and an overly conservative model caused results to become nonsignificant. Thus, the case for any one of these covariates as

[2] Attention problems are strongly negatively associated with self-control and positively associated with impulsiveness (Swing et al., 2010) and impulse control is considered by some to be the defining feature of ADHD (Barkley, 1997) making self-control and impulsiveness useful indicators of attention problems.

alternative explanations remains weak but is nonetheless a valid hypothesis. It is therefore valuable to continue to test several variables (e.g., sex, age, race, and socioeconomic status [SES]) as third variable explanations. For example, boys typically spend more time playing video games than girls (especially violent games) and are also more frequently diagnosed with attention disorders. The link between video games and attention disorders could thus be a spurious effect of these two potentially unrelated facts. Likewise, some other variable, such as race or SES, might predict parental permissiveness regarding video game use, as well as predisposing other adverse home conditions that are the environmental causes of attention problems. In this case, high levels of video game playing would be just one more consequence of the ineffective parenting that is truly causing attention problems. Another possibility is that both increasing video game use and increasing attention problems are normative changes with age. The inclusion of sex, age, race, and SES as covariates allows these potential alternative explanations to be tested and possibly eliminated.

In order to clarify the support for each of these explanations, we collected longitudinal data from a sample of children and adolescents. Participants reported their amount of video game playing, violent video game exposure, and completed measures of attention problems and impulsiveness. Several individual difference covariates were also measured, allowing for tests of some potential third variable explanations. To the extent that overall video game playing is associated with attention problems and impulsiveness, the displacement hypothesis would be supported. If violent video game exposure is uniquely associated with attention problems and impulsiveness (beyond simply the amount of video game playing), this would support the excitement hypothesis. If attention problems and impulsiveness predict increased subsequent video game playing, even when earlier video game playing is statistically controlled, this would support the attraction hypothesis. If controlling for a demographic covariate reduces the video game and attention problems/impulsiveness link to zero, this would support the third variable hypothesis, particularly if this remains true with only the relevant covariate in the model (without the other covariates and only one media variable).

Method

Participants

This study included 3,034 children/adolescents from 12 different schools in Singapore with a 99% response rate. Participants were ages 8–17 (mean [*M*] = 11.2, standard deviation [*SD*] = 2.1) at the first wave of data collection, starting in Grades 3, 4, 7, and 8. Children completed questionnaire measures in their classrooms in three waves (W1, W2, & W3), each 1 year apart. Questionnaire data were available for 3,034, 2,360, and 2,232 participants for W1, W2, and W3, respectively. Parent consent and child assent were gathered. Data were collected by classroom teachers and school research coordinators, with direction from trained research personnel. The questionnaires had been pretested with hundreds of children in three schools (not included in the present sample) to ensure comprehensibility.

Video Games

At each wave, participants indicated how many hours they played video games during each of three time periods (morning, afternoon, and evening) on a typical school day and on a typical weekend, from which we calculated the average weekly video game playing time. Video game playing showed excellent internal reliability across time periods and days (alphas of .90, .88, and .87 at W1, W2, and W3, respectively). Average weekly video game playing also showed strong test–retest correlations (r = .36 and r = .46 from W1 to W2 and W2 to W3, respectively). This suggests that this measure also has adequate test–retest reliability, although it is certainly likely that amount of gaming could change across time. Participants also listed the three video games that they play the most at each wave and indicated how often they killed creatures in each game on a 4-point scale (*never*, *seldom*, *often*, *almost always*) as well as how often they killed players in the game on the same scale. Violent video game exposure was computed based on the average amount of killing creatures and players in each of the three games. Violent video game exposure also

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showed adequate internal reliability (alphas of .77, .75, and .76 at W1, W2, and W3, respectively). Video game violence exposure scores also showed strong test–retest correlations (r = .38 and r = .46 from W1 to W2 and W2 to W3, respectively) indicating adequate test–retest reliability, although again there is no need for children to be consistent in their violent game play across years.

Attention Problems

Participants completed the Current ADHD Symptoms Scale Self-Report, an 18-item measure of inattention and hyperactivity symptoms, at W2 and W3 only (University of Massachusetts Medical School, 2011). This measure requires participants to indicate how often they exhibit symptoms such as "Fail to give close attention to details or make careless mistakes in my work" or "Blurt out answers before questions have been completed." Each question is answered on a 4-point scale (*never or rarely*, *sometimes*, *often*, or *very often*). Scores on the Current ADHD Symptoms Scale Self-Report showed excellent inter-item reliability in the present sample (alphas of .92 and .93 at waves 2 and 3, respectively). Scores on this scale also showed considerable stability across waves (r = .47 from waves 2 to 3) supporting the test–retest reliability of this scale.

Participants also completed 14 items from the Barratt Impulsiveness Scale-11, a measure of impulsiveness, at W1, W2, and W3 (Patton, Stanford, & Barratt, 1995). This included items "I often make things worse because I act without thinking" and "I concentrate easily" (reversed). Questions were answered on a 4-point scale (*strongly disagree*, *disagree*, *agree*, or *strongly agree*). These items showed adequate inter-item reliability in the present sample (alphas of .62, .73, and .65 at W1, W2, and W3, respectively). Impulsiveness scores showed strong test–retest correlations (r = .45 and r = .49 from W1 to W2 and W2 to W3, respectively), indicating adequate test–retest reliability. The ADHD symptom scores were strongly correlated with impulsiveness scores (r = .48 and r = .47 at W2 and W3, respectively) providing evidence of the convergent validity of each measure.

School performance, as measured by self-reported scores from the most recent exam in four different school subjects (English, math, science, and second language) also served as a useful outcome for establishing the predictive validity of the measures of attention problems and impulsiveness, given that previous research has shown individuals with ADHD to underperform academically (Barry et al., 2002). Attention problem scores were associated with poorer performance on the recent exams (r = −.24 and r = −.26 at W2 and W3, respectively). Impulsiveness scores were also associated with poorer exam performance (r = −.19, r = −.18, and r = −.17 at W1, W2, and W3, respectively). These small to moderate negative correlations demonstrate the predictive validity of the attention problems and impulsiveness scores.

Demographics

Participants reported sex, age, and race (coded as majority vs. minority). Participants reported the educational achievement of their mother and father as well as the type of home they lived in. Housing type, which is classified by the size of residence (e.g., one- to two-room public housing, three-room public housing, etc.), is a standard demographic characteristic in studies on Singaporean youth as a proxy indicator of socioeconomic status (SES) in the Singaporean context (Ho & Yip, 2002). Mother's and father's educational achievement were each standardized and combined to compute parental education. Mother's and father's educational achievement were strongly correlated with each other (r = .65) and also with housing type (r = .29 and r = .33 for mothers and fathers, respectively), indicating that these measures have good internal reliability. The SES was computed based on the parental education (standardized) and the rank order of their housing type (standardized).

Results

Bivariate correlations were computed for video game exposure, video game violence, impulsiveness, attention problems, sex, age, race, and SES at all applicable waves (see Table 1). The weighted averages of the bivariate correlations of video game exposure and video game violence with impulsiveness and attention problems from all relevant waves are reported in Table 2. These bivariate correlations (from r = T1 T2

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Table 1
Bivariate Correlations of Video Game, Attention Problems, and Individual Difference Measures

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. W1 VGE	.90													
2. W1 VGV	.25	.77												
3. W1 impulse	.16	.16	.62											
4. W2 VGE	.36	.19	.14	.88										
5. W2 VGV	.14	.38	.07**	.24	.75									
6. W2 impulse	.13	.11	.45	.15	.14	.73								
7. W2 attention	.18	.15	.32	.19	.18	.48	.92							
8. W3 VGE	.36	.14	.15	.46	.19	.18	.23	.87						
9. W3 VGV	.15	.37	.09	.20	.46	.07**	.14	.23	.76					
10. W3 impulse	.12	.08	.43	.09	.05	.49	.37	.15	.10	.65				
11. W3 attention	.16	.15	.33	.17	.15	.35	.47	.25	.22	.47	.93			
12. Sex	.06**	.32	.05*	.07**	.38	.02x	.08	.04+	.40	.00x	.08	—		
13. Age	.11	.12	.18	.13	.12	.15	.11	.13	.12	.11	.21	.01x	—	
14. Race	–.02x	–.01x	.00x	–.03x	–.05*	.04+	.09	.03x	–.06*	.05*	.13	–.08	–.03x	—
15. SES	–.09	.01x	–.02x	–.11	.04+	–.04*	–.09	–.14	.04+	–.02x	–.06**	.22	.03+	–.15

Note. VGE = weekly video game exposure; VGV = video game violence; impulse = impulsiveness; attention = attention problems; sex (female = 0, male = 1); race (majority vs. minority); SES = socioeconomic status. Coefficient alphas are reported on the diagonal. *n* from 1,639 to 3,034 (mean *n* of 2,394).
All correlations are significant ($p < .001$) except where specified. * $p < .05$. ** $p < .01$. + $p < .10$. x $p > .10$.

.14 to $r = .22$) are in the small to moderate range (as would be predicted for an environmental risk of attention problems).

In order to compare total video game playing and video game violence as predictors of attention problems and impulsiveness, four general linear models were computed (see Tables 3 and 4). Models 1 and 2 compare total video game exposure (VGE) and video game violence (VGV) as predictors of attention problems, with sex, age, race, and SES included as covariates. Model 1 uses the average of W2 and W3 for VGE, VGV, and attention problems. Model 2 tests the time-lagged video game effects by using the W2 measure of VGE and VGV, W2 attention problems as a covariate, and W3 attention problems as the outcome. Models 3 and 4 are similar but impulsiveness is the outcome (W1, W2, and W3 averages in Model 3 and W1 impulsiveness as a covariate and W3 impulsiveness as the outcome in Model 4). These models are a conservative test of video game effects on attention problems and impulsiveness. In Models 1 and 3, both VGE and VGV uniquely predict attention problems and impulsiveness, respectively, providing some support for both the excitement and displacement hypotheses. However in Models 2 and 4, VGE (but not VGV) remains significant suggesting that total video game exposure is a more robust predictor of attention problems and impulsiveness than violent gaming.

A path analysis was computed using Amos 7 to test the time-lagged effects of total VGE on attention problems as well as the effect of attention

Table 2
Bivariate Correlations of Video Game Variables and Attention Problems/Impulsiveness

	Weighted r[1]	95% CI	Corrected r[2]	Odds ratio[3]	95% CI
VGE-impulse	0.16	0.12–0.20	0.20	1.51	1.36–1.67
VGV-impulse	0.14	0.10–0.18	0.19	1.43	1.29–1.59
VGE-attention	0.22	0.18–0.26	0.25	1.77	1.59–1.97
VGV-attention	0.20	0.16–0.24	0.24	1.67	1.51–1.86

Note. VGE = video game exposure (total hours per week); VGV = video game violence; impulse = impulsiveness; attention = attention problems.
[1] Weighted *r*: Correlation of variables averaged, weighted by sample size. [2] Corrected *r*: Weighted correlation corrected for attenuation due to reliability (Murphy & Davidshofer, 1988). [3] Odds ratio: Conversion assumes variables split at their medians (Bonett, 2007).

Table 3
General Linear Model of Total Video Game Exposure and Video Game Violence as Predictors of Attention Problems

	Model 1				Model 2			
	Dependent variable: Attention problems				Dependent variable: W3 attention problems			
	F	*df*	*p*	Partial *r*	*F*	*df*	*p*	Partial *r*
VGE	47.47	1, 1457	.000	.18	4.28	1, 1702	.039	.05
VGV	22.74	1, 1457	.000	.12	2.02	1, 1702	.156	.03
Sex	1.96	1, 1457	.162	.04	4.78	1, 1702	.029	.05
Age	34.88	1, 1457	.000	.15	62.80	1, 1702	.000	.19
Race	50.46	1, 1457	.000	.18	22.06	1, 1702	.000	.11
SES	4.82	1, 1457	.028	.06	0.96	1, 1702	.327	.02
W2 attention problems					293.35	1, 1702	.000	.38

Note. W = wave; VGE = video game exposure (total hours per week) based on the average of W2 and W3 in Model 1 and W2 only in Model 2; VGV = video game violence based on the average of W2 and W3 in Model 1 and W2 only in Model 2.

problems on total VGE (see Figure 1). This model showed a good fit to the data, $\chi^2(6) = 14.86$, $p = .021$, normed fit index (NFI) = .989, comparative fit index (CFI) = .993, root means square error of approximation (RMSEA) = .029, 90% confidence interval (CI) = .011, .049. A similar path analysis was computed to test the time-lagged effects of total VGE on impulsiveness as well as the effect of impulsiveness on total VGE (see Figure 2). This model also showed good fit to the data, $\chi^2(12) = 33.67$, $p = .001$, NFI = .969, CFI = .980, RMSEA = .031, 90% CI: .019, .044. Figures 1 and 2 show a small effect of VGE on subsequent attention problems and impulsiveness even when sex, age, race, SES, and earlier attention problems or impulsiveness are controlled. Figures 1 and 2 also show a small effect of attention problems and impulsiveness on subsequent VGE. This indicates potentially bidirectional causality between video game playing and attention problems/impulsiveness. All four general linear models and both path models include at least one significant video game predictor, suggesting that the association of VGE with impulsiveness and attention problems cannot simply be explained by sex, age, race, or SES as third variables.

Discussion

Consistent with most previous research, the present study found video game playing to be associated with greater subsequent attention

Table 4
General Linear Model of Total Video Game Exposure and Video Game Violence as Predictors of Impulsiveness

	Model 3				Model 4			
	Dependent variable: Impulsiveness				Dependent variable: W3 impulsiveness			
	F	*df*	*p*	Partial *r*	*F*	*df*	*p*	Partial *r*
VGE	32.61	1, 1195	.000	.16	4.34	1, 1707	.037	.05
VGV	14.05	1, 1195	.000	.11	0.01	1, 1707	.914	.00
Sex	2.70	1, 1195	.101	.05	2.19	1, 1707	.139	.04
Age	14.98	1, 1195	.000	.11	5.32	1, 1707	.021	.06
Race	9.92	1, 1195	.002	.09	7.31	1, 1707	.007	.07
SES	0.13	1, 1195	.722	.01	0.05	1, 1707	.820	.01
W1 impulsiveness					343.66	1, 1707	.000	.41

Note. W = wave; VGE = video game exposure (total hours per week) based on the average of W1, W2, and W3 in Model 3 and W1 only in Model 4; VGV = video game violence based on the average of W1, W2, and W3 in Model 3 and W1 only in Model 4.

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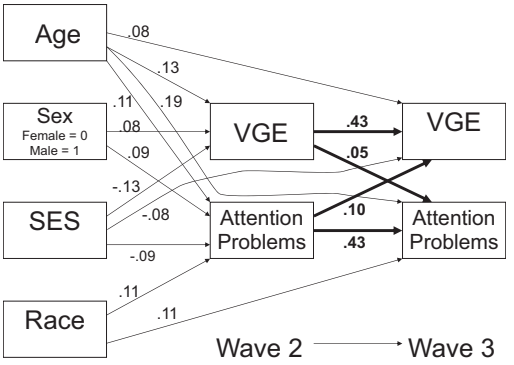

Figure 1. Video game playing and attention problems as bidirectional causal variables. Path coefficients are standardized. All paths are significant.

problems, even when earlier attention problems were statistically controlled. There was some evidence that violent video game content added uniquely to predicting attention problems beyond the total amount of time played. Specifically, video game violence exposure was uniquely associated with attention problems and impulsiveness when sex, age, race, and SES were statistically controlled. However, total time spent playing video games was the more robust predictor in this sample, predicting attention problems and impulsiveness even when earlier attention problems/impulsiveness were statistically controlled as well, providing stronger support for the displacement hypothesis than for the excitement hypothesis. Future research should continue to examine potential content effects. The current study is also the first to test the attraction hypothesis (i.e., individuals who are impulsive or have attention problems seek out video games). The data were consistent with this hypothesis as well. These findings provide evidence for bidirectional causality: children with greater impulsiveness and attention problems spend more time playing video games, which in turn increases subsequent attention problems and impulsiveness. This finding does not alter the cause for concern about the potential for video games to contribute to the development of attention problems.

The longitudinal design allowed the present study to provide stronger evidence of causality than a single time point study, but these data were nonetheless observational. Thus it remains possible that some third variable not included accounts for one or both directions of apparent causality. However, several third variables have been ruled out thus far and to date there is no substantial evidence in favor of any particular third variable explanation. Furthermore, controlling for earlier attention problems or impulsivity also controls for all of the variables that caused them in the first place, including all prior genetic and environmental factors. This further weakens the third variable hypothesis as an alternative explanation. The study would also have been strengthened if we had been able to include the ADHD symptoms scale at Wave 1 also, but were unable to due to time constraints in the classroom.

The effects observed in the present study are admittedly small in a statistical sense ($\beta = .05$), but several facts should be considered regarding these effects. First, these effects come from conservative analyses that likely underestimate the true effect just as the bivariate correlations are likely to be overestimates. Some children with attention problems are also likely to underestimate their problems in self-reports, as compared with the reports of adults such as parents and teachers (Owens, Goldfine, Evangelista, Hoza, & Kaiser, 2007). This would lead estimates of the link between video games and attention problems to be underestimated when based on child self-reports. Future research might address these self-report issues by including parent reports or child time logs for assessing video game playing as well as parent and teacher reports of attention problems or impul-

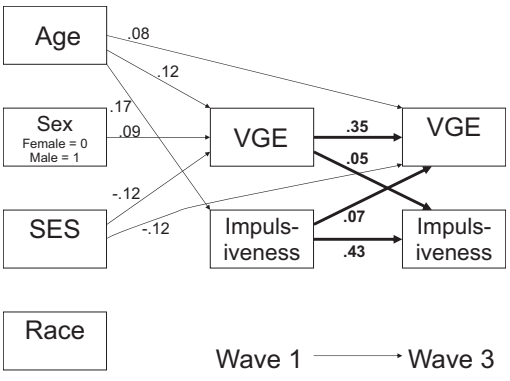

Figure 2. Video game playing and impulsiveness as bidirectional causal variables. Path coefficients are standardized. All paths are significant.

siveness. It should be noted, however, that small effects such as those obtained here can be important when they apply to a large population as is the case with video games. In fact, even the most conservative estimates of electronic media effects on attention are similar in magnitude to specific genes, such as LPHN3, the markers for which increase the odds of inattention by approximately 1.23 yet are considered to have great practical importance (Arcos–Burgos et al., 2010). Finally, the size of the effect is consistent with theoretical predictions, as environmental factors should explain only a small amount of variance in attention problems.

As with all nature–nurture questions, the answer ultimately is that both matter. For the past 30 years, most of the research on attention problems has focused on biological and genetic factors rather than on environmental factors. This allowed for rapid advances in drug therapies, but has also caused many researchers and members of the general public to assume that impulsivity and attention problems were not modifiable by experience. This is unfortunate, as it means we have only focused on part of the solution. Furthermore, many problems with genetic bases are clearly enhanced by environmental triggers. By understanding some of the environmental influences, we can develop more effective solutions for children and parents. More research is clearly needed on the environmental factors, especially factors that are easily modified by parents, such as screen time.

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