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The role of media entertainment in children's and adolescents' ADHD-related behaviors: A reason for concern?

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Chapter 5

Examining bi-directional longitudinal relationships between adolescents' media use and ADHD-related behaviors

Abstract

This study aimed to examine causality in the relationship between media use (i.e., television viewing and gaming) and ADHD-related behaviors. Specifically, we examined reciprocity in this relationship, and differences due to content (i.e., general media use versus violent media use), form (i.e., television versus games) and individual factors (i.e., gender and age). Using three-wave cross-lagged survey data of 1,032 adolescents (10-14 years at T1), we found that violent, but not general, media use predicted ADHD-related behaviors. ADHD-related behaviors, in turn, predicted both general and violent media use. There was one difference between television viewing and gaming: The effect of ADHD-related behaviors on general media use only applied to gaming, and not television viewing. There were no gender or age differences in any of the analyses. Our findings suggest a reinforcing spiral effect for violent media use and stress the importance of distinguishing form and content in research on the media-ADHD relationship.

An increasing number of empirical studies have addressed the relationship between children's use of entertainment media and attention-deficit/hyperactivity disorder (ADHD) or ADHD-related behaviors. ADHD is a developmental disorder typified by extreme levels of inattention, hyperactivity, and impulsivity (American Psychiatric Association, 2013), causing significant social and academic impairments (e.g., Daley & Birchwood, 2010; Wehmeier, Schacht, & Barkley, 2010). Although ADHD is considered a clinical diagnosis, its characteristic behaviors occur in quantitatively different levels in the general population. Therefore, it is frequently argued that ADHD is best viewed as the extreme of a continuum (Larsson, Anckarsater, Råstam, Chang, & Lichtenstein, 2012; Levy, Hay, McStephen, Wood, & Waldman, 1997). We share this continuum-based perspective, and in doing so, use the term *ADHD-related behaviors* as opposed to ADHD in this text.

Research on media use (e.g., television viewing and game playing) and ADHD-related behaviors has been fueled by widespread concern among scholars, parents, and healthcare professionals that frequent media use may elicit ADHD-related behaviors (e.g., Christakis, 2009). Indeed, a recent meta-analysis of 45 empirical studies showed a small positive relationship between ADHD-related behaviors and children's media use (Nikkelen, Valkenburg, Huizinga, & Bushman, 2014). However, we are far from a detailed understanding of the relationship between ADHD-related behaviors and media use. For one thing, we lack knowledge concerning the causality of this relationship. The majority of existing studies have been correlational in nature (e.g., Ferguson & Olson, 2013; Lingineni et al., 2012; Shin, 2004), thus providing no indicator of relationship direction. The longitudinal studies that do exist have been inconclusive as to whether or not a relationship exists over time (e.g., Gentile, Swing, Lim, & Khoo, 2012; Johnson, Cohen, Kasen, & Brook, 2007; Swing, Gentile, Anderson, & Walsh, 2010). Furthermore, the majority of existing longitudinal studies has only examined the effect of media use on ADHD-related behaviors, without considering the reverse effect of ADHD-related behaviors on media use. This is surprising given that scholars have argued that children with high ADHD-related behaviors may be more attracted to media in general and to certain media content (Acevedo-Polakovich, 2005; Miller et al., 2007). Of course, it is also possible that both causal pathways (i.e., media use as a cause or as an effect of ADHD-related behaviors) work simultaneously in a transactional process (Slater, 2007; Valkenburg & Peter, 2013a). Finally, we know little about whether the relationship between media use and ADHD-related behaviors is uniform, or instead whether it is dependent upon the content of media (e.g., all media content versus specific content types), the media format (e.g., television versus videogames), or individual characteristics (e.g., gender, age).

Using data from a three-wave longitudinal study among adolescents, the present study aims to address these gaps by examining whether there is a longitudinal relationship between ADHD-related behaviors and media use and if so, what the causal direction of this relationship is. Furthermore, we investigate whether media content, media types, and individual differences may moderate this relationship.

Causality in the Relationship between Media Use and ADHD-related Behaviors

Longitudinal research on the media-ADHD relationship has been mainly conducted from a media *effects* perspective (Nikkelen et al., 2014). Studies adopting this perspective assume that media use can affect one's behavior. The existing literature identifies several explanations for why media use may elicit ADHD-related behaviors. Most typically, these explanations posit that entertainment media is too stimulating and induces heightened arousal levels (e.g., Sigman, 2007). Over time, children who use media frequently may become accustomed to the repeated high stimulation that they receive (Ballard, Hamby, Panee, & Nivens, 2006). As a result, in less stimulating environments (e.g., the classroom), these children may experience a state of so-called "underarousal", a state reflected in feelings of dullness and boredom (Humphreys & Revelle, 1984). Underarousal, in turn, is frequently argued to underlie ADHD-related behaviors. For example, it can lead to attention problems as a certain level of arousal is needed to remain attentive. Further, one may act restless or impulsive in order to increase arousal to a more pleasant level (Nigg, 2006; White, 1999). Although the majority of longitudinal studies have indeed found a positive relationship between initial media use and subsequent ADHD-related behaviors (e.g., Landhuis, Poulton, Welch, & Hancox, 2007; Swing et al., 2010), some studies did not find such an effect (e.g., Obel et al., 2004; Tomopoulos et al., 2007). As such, whether media use influences subsequent ADHD-related behaviors remains somewhat unclear.

Aside from the arguments for why media use may cause ADHD-related behaviors, it has also been hypothesized that children with high ADHD-related behaviors are particularly attracted to entertainment media (e.g., Miller et al., 2007). From this *selective exposure* view, ADHD-related behaviors are expected to influence media use. The main argument for this again relates to children's arousal, and more specifically to under arousal (Lazzaro et al., 1999), which may cause children with heightened ADHD-related behaviors to seek out stimulating activities to alleviate their arousal level (Roberti, 2004). Media use may be such an activity because of its potentially arousing features. Longitudinal research considering this causal direction is scarce, and shows inconsistent findings. Whereas one study found a positive effect of ADHD-related behaviors on the

amount of game use (Gentile et al., 2012), two studies indicated no effect upon television viewing (Johnson et al., 2007; Stevens, Barnard-Brak, & To, 2009).

Importantly, the two theoretical pathways (i.e., media use as a cause or consequence of media use) need not be mutually exclusive. Several media effects theories, such as the Differential Susceptibility to Media Effects Model (Valkenburg & Peter, 2013a) and the Reinforcing Spirals Model (Slater, 2007), stress the importance of examining reciprocal relationships when investigating media-behavior relationships, as they can influence and reinforce each other. For example, media use might induce ADHD-related behaviors, which in turn may increase media use itself. To our knowledge, there have been three longitudinal studies that have concurrently tested both causal directions. One study examining the relationship between ADHD-related behaviors and video gaming among adolescents found evidence for both causal pathways (Gentile et al., 2012). A second study found evidence for an effect of television viewing on adolescents' ADHD-related behaviors, but not the reverse effect (Johnson et al., 2007). A third study, measuring television use among young children, found evidence for neither direction of effects (Stevens et al., 2009). Due to these inconsistent findings, it remains unclear whether ADHD-related behaviors and media use are related over time and what the causal direction of this relationship is. Therefore, in this study we will parse out both the content (i.e., general use versus violent use) and the form of media (i.e., television versus games) to gain more insight into the reciprocal relationship between media use and ADHD-related behaviors.

Differences in Content and Forms of Media

Previous longitudinal studies examining the relationship between media use and ADHD-related behaviors did not only differ in their expectations and findings concerning causality, but also in the content and format of media they investigated. Most studies have measured overall media use (e.g., weekly hours of media use per week), arguing that media use in general is highly stimulating. However, several authors have argued that research should particularly focus on the effects of violent media content on ADHD-related behaviors since this form of content is thought to be especially arousing (Fleming & Rickwood, 2001; Maass, Lohaus, & Wolf, 2010; Zimmerman & Christakis, 2007). Of course, the rationale for the effect of violent media content on ADHD-related behaviors may also work in the reverse way. Specifically, violent media content – by virtue of its arousing properties – may be particularly attractive for children with high ADHD-related behaviors.

To date, only one study has examined the bi-directional relationship between both general and violent media use and ADHD-related behaviors (Gentile et

al., 2012). This study found that general gaming was a more robust predictor of adolescent's ADHD-related behaviors than violent gaming. The reverse effect of ADHD-related behaviors on gaming, however, was only examined for general, and not violent gaming. Therefore, it remains unclear whether the relationships between media use and adolescents' ADHD-related behaviors can be attributed to media use in general, or to violent content in particular. To that end, in the present study, differences between general media use and violent media content are investigated in relationship to ADHD-related behaviors for both causal pathways.

Aside from content, the format of media (i.e., television or games) might also play a role in the media-ADHD relationship. Watching television and playing games are media activities that differ from each other in several respects. In the context of ADHD-related behaviors, two differences are particularly relevant. First, television is considered a relatively passive form of media use, as the viewer merely has to observe what happens, whereas gaming is considerably more active, as the player continuously has to act for the game to proceed (Nakatsu, Rauterberg, & Vorderer, 2005). A second, closely related difference is that gaming is generally more interactive in the sense that the player participates in and becomes part of the virtual world. In contrast, when watching television, there is more distance between the viewer and the characters (Klimmt, Hefner, & Vorderer, 2009). Because of this higher activity and interactivity, gaming in general may elicit higher arousal levels than television viewing. As high arousal levels have been hypothesized to elicit ADHD-related behaviors, and because children with high ADHD-related behaviors are argued to seek out arousing activities, both causal relationships between media use and ADHD-related behaviors may be stronger for game playing compared to television viewing. In contrast with these expectations, the meta-analysis by Nikkelen et al. (2014) did not find a moderating effect of media type on the relationship between media use and ADHD-related behaviors. However, although in this meta-analysis a distinction was made between television and games, potential differences between overall and violent use within these two media formats (i.e., overall versus violent television viewing and overall versus violent game use) could not be analyzed. Given the arguments that especially the use of violent content (compared to overall use) and gaming (compared to television viewing) may be related to ADHD-related behaviors, it is possible that violent gaming may be especially linked to ADHD-related behaviors. Therefore, in addition to examining differences between overall media use and violent media use, we examine differences between television and gaming.

Individual Differences

While media format and content type may potentially influence the bi-directional relationship between media use and ADHD-related behaviors, current media effect theories (Slater, 2007; Valkenburg & Peter, 2013a) would posit that individual differences may also affect this relationship. In the context of media use and ADHD-related behaviors, there are two individual difference variables that are of particular interest: gender and age.

To date, research examining media use and ADHD-related behaviors most often controls for gender in statistical analyses (e.g., Foster & Watkins, 2010; Swing et al., 2010). This is because boys generally display more ADHD-related behaviors (Willcutt, 2012), are more attracted to violent media content (Valkenburg & Janssen, 1999), and tend to spend more time playing games (Rideout, Foehr, & Roberts, 2010). However, by controlling for gender rather than identifying whether gender may moderate the relationship between media use and ADHD-related behaviors, the magnitude of the effect is potentially underestimated for either boys or girls (Valkenburg & Peter, 2013b). Nikkelen et al.'s (2014) meta-analysis did provide some evidence for a possible moderation of gender, showing that the effect size between media use and ADHD-related behaviors increased as the proportion of boys in the studies increased. This suggests that the association between media use and ADHD-related behaviors may be particularly robust for boys. Indeed, a cross-sectional study among young children found a positive relationship between ADHD-related behaviors and general amount of TV viewing and amount of arousing content viewing among boys only (Nikkelen, Vossen, & Valkenburg, 2015). Therefore, the present study examines gender differences in all aforementioned relationships.

Next to gender, adolescents' age may also influence the relationship between media use and ADHD-related behaviors. Adolescence is characterized by great hormonal (Blakemore & Choudhury, 2006) and brain changes (Giedd, 2008). In particular, the onset of puberty is marked by enormous developmental changes (Crone & Dahl, 2012). Therefore, adolescents' behavior may be most susceptible to change at the beginning of adolescence, when puberty begins and developmental changes are rapid. As such, the relationship between media use and adolescents' ADHD-related behaviors may be stronger in younger than in older adolescents. This potential moderating effect of adolescents' age has not been studied in previous research. We investigate the moderating role of age in all aforementioned relationships.

Method

Sample and Procedure

To address our study aims, we employed a cross-lagged panel design using three-wave survey data from adolescents and one of their parents. After receiving approval from the sponsoring institution's Institutional Review Board, data were collected by a private Dutch research company between September 2012 and December 2014, with one-year intervals between data waves. The research company recruited families from their existing pool of approximately 60,000 households, originally sampled randomly among the Dutch population. Because this study is part of a larger research design in which the inclusion of sibling data was necessary, the research company recruited 516 families with at least two adolescents between 10 and 14 years old from their panel members. Two adolescents from each family participated in the study, resulting in our total sample of 1,032 adolescents (49.7% female) with a mean age of 12.39 ($SD = 1.38$) at the initial data wave. Of our total sample of 1,032 respondents, 945 participated at the second data wave, and 885 at the third data wave.¹ Thus, the attrition rate was 8.4% for wave 2 and 6.3% for wave 3.

Measures

Violent media use. Violent media use was measured via self-report using direct estimates, which has been proven to be a reliable and valid method for working with adolescents (Fikkers, Piotrowski, & Valkenburg, 2015). We used separate measures for violent television viewing and violent gaming, with two items each: (1) "How often do you watch television programs [play games] that contain violence?" and (2) "On the days that you watch television programs [play games] that contain violence, how much time do you spend on this per day?" We presented respondents with the following definition of violence: "All violence (for example, fighting and shooting) that living beings (for example, humans and monsters) do to each other." Response options for the first item ranged from 0 = *never* to 7 = *7 days per week*. The second item was answered by filling in hours and minutes. The two items were multiplied to calculate violent television viewing and violent game playing in hours per week. Subsequently, these two variables were summed to create one variable representing violent media use in hours per week.

Because the items about duration of violent TV and game use were open questions, and teens could fill in up to 24 hours, the measures of total violent media use contained some extreme values. To reduce the effect of these extreme

¹In around 2% of cases in each data wave, only parent-report measures or adolescent-report measures were available in a given data wave. These cases are still included in the analyses.

values, values $> 3SD$ from the mean were recoded to the value $M + 3SD$. Stability coefficients between waves for each measure (i.e., violent television use, violent game use, and violent media use) ranged from $r = .39$ (between W1 and W3 violent television use) to $r = .66$ (between W2 and W3 violent game use).

Overall media use. Overall media use was estimated using self-reports, with a measure similar to the violent media use measure. Again, we asked separate questions for television viewing and gaming, with two items each: (1) “How often do you watch television programs [play games]?” and (2) “On the days that you watch television programs [play games], how much time do you spend on this per day?” Response options to the two items were the same as those for violent media use. The two items were multiplied to calculate separate measures of overall television viewing and overall game playing in hours per week, which were then summed to create one variable representing overall media use in hours per week. As with violent media use, values $>3SD$ from the mean were recoded to the value $M + 3SD$. Stability coefficients between waves for each measure (i.e., overall television use, overall game use, and overall media use) ranged from $r = .42$ (between W1 and W3 overall television use) to $r = .60$ (between W1 and W2 overall game use).

ADHD-related behaviors. ADHD-related behaviors were measured using the Dutch ADHD questionnaire (Scholte & Van der Ploeg, 2010), which is a parent-report measure. This questionnaire consists of 18 items, six for each of the three domains of ADHD-related behaviors (i.e., attention problems, hyperactivity, and impulsivity). The items closely match the ADHD criteria in the DSM-V (American Psychiatric Association, 2013) and have shown good reliability and validity (Scholte & Van der Ploeg, 2010). Sample items are “[name teen] has trouble organizing activities and tasks” (attention problems), “[name teen] is continuously in motion, like he/she is driven by a motor” (hyperactivity), and “[name teen] blurts out an answer before the question is finished” (impulsivity). Items were rated on a five-point scale with 0 = *never*, 1 = *sometimes*, 2 = *regularly*, 3 = *often*, 4 = *very often*. Total scores for ADHD-related behaviors were created by summing all 18 items. We used the total ADHD scale in our models instead of the three separate subscales because the subscales are highly correlated (with r 's ranging from .69 to .79) which would lead to problems of multicollinearity. Cronbach's alpha of the total ADHD measure was .94 in all the three data waves. See Table 1 for means and standard deviations for the three data waves. Stability coefficients between waves ranged from .79 to .82.

Control variables. Both adolescent's media use and their ADHD-related behaviors have been shown to be influenced by age (Valkenburg & Cantor, 2001; Willcutt, 2012), gender (Gershon & Gershon, 2002; Olson et al., 2007), and socio-

economic status (SES, Gorely, Marshall, & Biddle, 2004; Zwirs et al., 2011). We therefore included these three variables as controls in our analyses, except in the moderation analyses in which either gender or age was used as a grouping variables instead of a control variable, while still controlling for the other two variables. Age was measured in years. Gender was coded as 0 = *boy*, 1 = *girl*. SES was a composite of parents' educational level and household income at the first data wave. Educational level referred to the highest educational level of the parent who completed the survey (1 = *no education*, 2 = *primary education*, 3 = *pre-vocational education*, 4 = *lower secondary education*, 5 = *higher secondary education*, 6 = *bachelor's degree*, 7 = *master's degree*). Household income referred to the net household income per month. Composite SES was calculated by converting the scores for educational level and household income into Z-scores and averaging these (range: -3.66 to 2.75, $M = -0.01$, $SD = 0.88$).

Statistical Analyses

In order to examine the longitudinal relationship between ADHD-related behaviors and overall and violent media use, we tested autoregressive cross-lagged models with three data waves using Structural Equation Modeling (SEM) in MPlus statistical software (Version 7, Muthén & Muthén, 1998-2012). Models were estimated using maximum likelihood with robust error estimation (MLR), with missing data. We used robust clustering to account for the dependency within our data (sibling data). First, we tested a cross-lagged model for the relationship between (1) ADHD-related behaviors, (2) overall media use, and (3) violent media use (see Figure 1). In this model, overall and violent media use represented the combined estimates of television viewing and video game playing. Overall and violent media use were analyzed in one model in order to parcel out their independent relationships. The model controlled for age, SES, and gender.

To examine gender and age differences, we conducted two multiple group analyses with either gender or age (10 to 11 year-olds [$N = 408$] versus 12 to 14 year-olds [$N = 624$]) as grouping variable. The multiple group analyses were conducted by estimating a model with all parameters allowed to vary between groups and comparing it to a model with the paths of interest constrained to be equal across groups (i.e., all bold paths in Figure 1). If the latter model provides a worse fit to the data, as tested by a chi-square difference test, this indicates that one or more pathways are different across groups. Chi-square change was measured using the Satorra-Bentler Scaled Chi-Square (Satorra & Bentler, 1994). The multiple group model for gender controlled for SES and age, whereas the multiple group model for age controlled for SES and gender. Second, to investigate whether the model for media use held for both television viewing and video game playing, separate

cross-lagged models were tested (a) for overall/violent television viewing and (b) for overall/violent video gaming. These two models controlled for age, SES, and gender. Subsequently, for both models, we analyzed gender and age differences using multiple group analysis as described above.

In all analyses, we evaluated model fit using the root mean square of approximation (RMSEA) and the comparative fit index (CFI). As the commonly reported chi-square statistic is often unreliable with large samples (Byrne, 2001), we favor the RMSEA and CFI as indicators of model fit. Generally, RMSEA values smaller than .05 and a CFI exceeding .95 indicate good model fit. Further, acceptable model fit is indicated by RMSEA values between .05 and .08 and CFI values between .90 and .95 (Byrne, 2001).

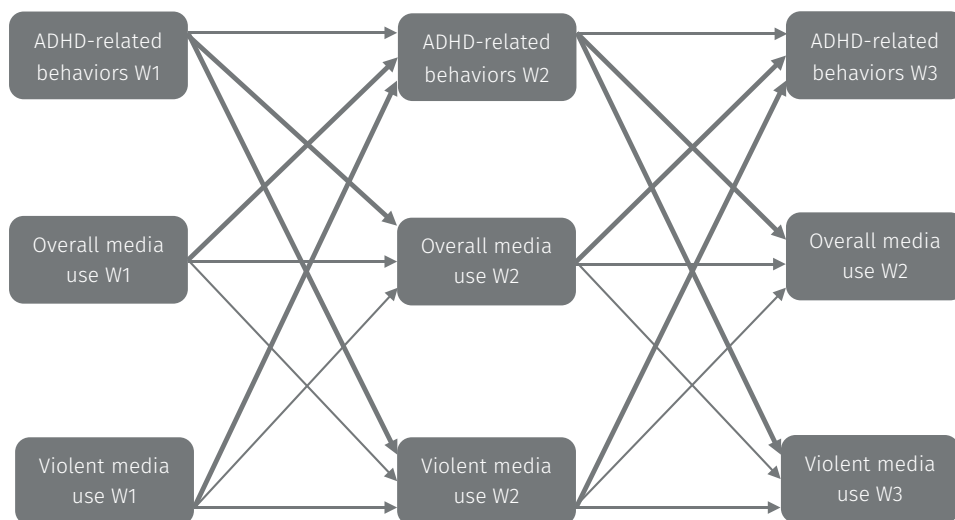


Figure 1 Simplified cross-lagged model for the relationship between ADHD-related behaviors, overall and violent media use across three waves. Paths in bold are the paths that were constrained in the multiple group analyses. Variables were controlled for age, gender, and SES (except in the multiple group analyses in which either gender or age was used as the grouping variable instead of a control variable), but these paths are not displayed for clarity.

Results

Descriptive Statistics

Table 1 displays the means (+SD) of our measures of media use and ADHD-related behaviors, separated by gender and data wave. Independent-samples t-tests indicated that boys consistently displayed more ADHD-related behaviors,

used more media overall (due to more game playing), and more violent media compared to girls. Table 2 displays the bivariate correlations among our measures of media use, ADHD-related behaviors, age, and SES. Across all data waves, we found positive correlations between ADHD-related behaviors and overall media use (particularly overall game use), as well as between ADHD-related behaviors and violent media use. Furthermore, adolescent's age was positively associated with violent media use. Finally, lower SES was related to more overall and violent media use.

Table 1 Means (SD) of the Main Study Variables, Separated by Data Wave and Gender.

	Wave 1		Wave 2		Wave 3	
	Boys	Girls	Boys	Girls	Boys	Girls
ADHD-related behaviors	17.96 (14.25)	13.65*** (11.88)	17.20 (14.35)	12.63*** (11.54)	15.35 (12.98)	12.05*** (11.49)
Overall TV use (hrs/wk)	13.11 (10.65)	12.36 (9.68)	11.28 (9.28)	11.40 (9.08)	10.62 (8.85)	10.69 (9.29)
Overall game use (hrs/wk)	10.97 (10.17)	5.15*** (7.19)	11.72 (10.56)	5.16*** (8.00)	12.09 (10.57)	4.01*** (7.76)
Overall media use (hrs/wk)	24.47 (17.37)	17.67*** (14.30)	23.05 (16.15)	16.63*** (13.83)	22.72 (15.43)	14.77*** (13.64)
Violent TV use (hrs/wk)	2.78 (3.91)	1.60*** (3.12)	3.60 (4.86)	1.64*** (2.89)	3.39 (3.60)	1.90*** (2.78)
Violent game use (hrs/wk)	5.00 (6.82)	0.46*** (1.80)	6.91 (8.64)	0.64*** (2.92)	7.06 (8.77)	0.65*** (2.76)
Violent media use (hrs/wk)	7.94 (9.58)	2.16*** (4.53)	10.80 (12.18)	2.34*** (5.16)	10.52 (10.78)	2.64*** (4.64)

Note. Asterisks indicate significant mean differences between boys and girls, tested using independent-samples t-tests.

*** $p < .001$

Cross-Lagged Model Testing

The estimation of our model for the relationship between ADHD-related behaviors, overall media use, and violent media use produced adequate model fit (CFI = .95, RMSEA = .08 [.07, .09]). As visualized in Figure 2, we found a positive relationship between violent media use at wave 1 and ADHD-related behaviors at wave 2 ($b^* = .07, p = .007, 95\% \text{ CI } [.02, .11]$). Moreover, we found a positive relationship between ADHD-related behaviors at wave 2 and overall media use at wave 3 ($b^* = .07, p = .025, 95\% \text{ CI } [.01, .14]$), and violent media use at wave 3 ($b^* = .12, p < .001, 95\% \text{ CI } [.05, .18]$). The multiple group analyses showed no significant difference in the model fit of the constrained model compared to the full model for gender ($\Delta\chi^2(8) = 10.82, p = .212$) nor for age ($\Delta\chi^2(8) = 8.48, p = .388$).

Table 2 Bivariate Correlations among Media Variables, ADHD-related behaviors, and Covariates

		ADHD-related behaviors			Gender	Age	SES
		W1	W2	W3			
Television	Overall W1	.07*	.03	.09*	-.04	.03	-.20***
	Overall W2	.06	.04	.07	.01	-.06	-.12***
	Overall W3	.04	.04	.08*	.00	-.01	-.15***
	Violent W1	.11***	.11**	.09*	-.17***	.16***	-.09***
	Violent W2	.11**	.11**	.11**	-.24***	.11**	-.04
	Violent W3	.12**	.14***	.11**	-.23***	.13***	-.12**
Games	Overall W1	.15***	.15***	.15***	-.31***	.05	-.08*
	Overall W2	.16***	.15***	.15***	-.33***	-.03	-.04
	Overall W3	.18***	.22***	.16***	-.40***	-.04	-.09**
	Violent W1	.13***	.13***	.09**	-.41***	.09**	-.07*
	Violent W2	.11**	.11**	.10**	-.44***	.04	-.09**
	Violent W3	.16***	.21***	.15***	-.44***	.05	-.08*
Media	Overall W1	.15***	.12***	.16***	-.21***	.06	-.17***
	Overall W2	.14***	.13***	.13***	-.21***	-.05	-.10***
	Overall W3	.15***	.17***	.15***	-.26***	-.03	-.16***
	Violent W1	.15***	.15***	.12**	-.36***	.14***	-.10**
	Violent W2	.12***	.12***	.11**	-.41***	.07*	-.07*
	Violent W3	.17***	.22***	.16***	-.43***	.09*	-.11**
Gender		-.16***	-.17***	-.13***			
Age		-.06	-.07*	-.10**	-.03		
SES		-.04	-.01	.00	.02	-.03	

Note. *** $p < .001$. ** $p < .01$. * $p < .05$

Separate Cross-Lagged Models for TV and Game Use.

The separate cross-lagged models for the relationship between ADHD-related behaviors and television and game use had adequate model fit (television: CFI = .94, RMSEA = .07 [.06, .08]; and games: CFI = .95, RMSEA = .08 [.07, .09]) Path coefficients for these separate models were similar, except for one particular difference: The model for game use showed a positive relationship between ADHD-related behaviors at wave 2 and overall game use at wave 3, ($b^* = .10$, $p = .002$, 95% CI [.04, .17]), whereas this path was not significant in the model for television use ($b^* = .01$, $p = .666$, 95% CI [-.05, .08]). The multiple group analyses for the model on TV use showed no significant difference in the model fit of the constrained model compared to the full model for gender, $\Delta\chi^2(8) = 5.88$, $p = .660$, nor for age, $\Delta\chi^2(8) = 8.11$, $p = .423$. For game use, the multiple group analysis also showed no significant difference for gender, $\Delta\chi^2(8) = 10.68$, $p = .221$ or age, $\Delta\chi^2(8) = 6.56$, $p = .585$.

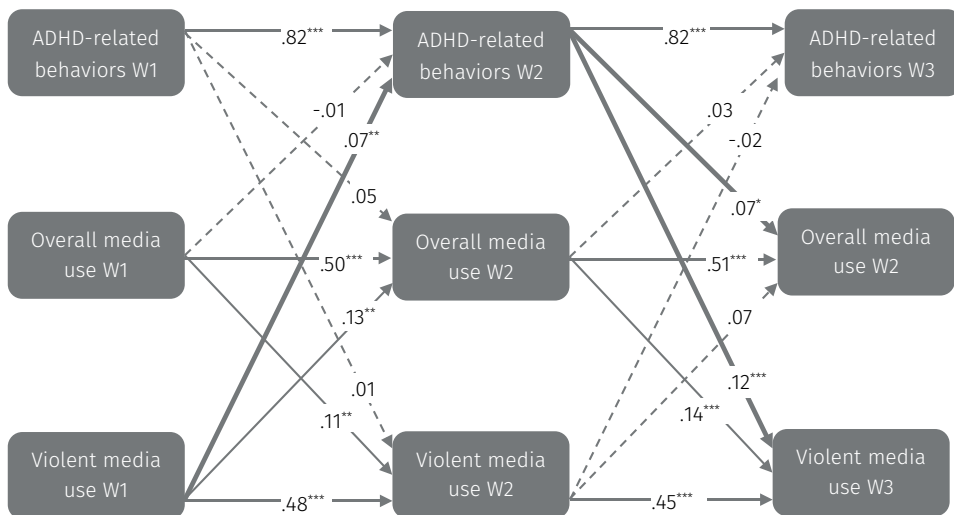


Figure 2 Cross-lagged relationships between ADHD-related behaviors and overall and violent media use across three waves. Coefficients represent standardized betas. The model controlled for gender, age and SES. The coefficients displayed are for the final model, with nonsignificant paths from control variables removed stepwise
 *** $p < .001$. ** $p < .01$. * $p < .05$.

Discussion

Despite the abundance of studies that have investigated the media-ADHD relationship, little is known about the causality and the specificity of this association. To clarify and extend this body of literature, the main aim of this study was to examine whether a relationship between media use and ADHD-related behaviors exists over time and if so, what the causal direction of this relationship is. Moreover, we examined the boundary conditions of this relationship, specifically asking whether the relationship between media and ADHD may differ by media content, media format, child age, or child gender. Using a three-wave cross-lagged design with a sample of young adolescents, our findings indicate that media can both serve as a cause and as an effect of ADHD-related behaviors, depending on the content and the form of media use.

Reciprocal Relationships for Overall and Violent Media Use

In this study, we investigated two potential perspectives: (1) the media *effects* perspective, whereby media use may lead to ADHD-related behaviors, and (2) the media *selection* perspective, whereby ADHD-related behaviors may predict

differences in media use. In line with the media effects perspective, this study shows that violent media use is related to subsequent increased ADHD-related behaviors. This finding was present only between Time 1 and Time 2, and was only present for violent media use – not overall media use. As such, it seems that violent media use specifically, and not media use in general, may elicit ADHD-related behaviors. Additionally, in line with the media selection perspective, this study demonstrated a longitudinal effect of ADHD-related behaviors on both general media use and violent media use between Time 2 and Time 3. This indicates that individuals with elevated ADHD-related behaviors show a subsequent increase in their amount of media use in general as well as in their violent media use. Taken the findings for both perspectives together, it seems that the relationship between violent media and ADHD may be a reciprocal one. In other words, violent media use can act both as a cause and as a consequence of ADHD-related behaviors. This finding is explained in terms of the arousal-inducing effect of violent content (Fleming & Rickwood, 2001) whereby violent content can elicit ADHD-related behaviors, but is also particularly attractive for adolescents with increased ADHD-related behaviors, thereby creating a negative cycle between the two.

Additionally, although we found that ADHD-related behaviors predicted general amount of media use, we found no support for the argument that general media use elicits ADHD-related behaviors. This finding is at odds with previous research that has shown longitudinal relationships between the amount of overall media use and subsequent ADHD-related behaviors (e.g., Johnson et al., 2007; Landhuis et al., 2007; Swing et al., 2010). However, the majority of these studies solely examined general media use, without controlling for its (violent) content. By measuring both general media use and violent media use simultaneously, we were able to obtain a clearer picture of this relationship. Based on the findings presented here, it is likely that the effect of general media use on subsequent ADHD-related behaviors found in previous studies may actually reflect an effect of violent media use on ADHD-related behaviors. That said, our findings in support of the selection hypothesis for general media use also suggest that there is something about media use in general – beyond the characteristics specific to violent media content – that may be particularly attractive to children who display high ADHD-related behaviors. An explanation may lie in the social problems that these children often experience. For example, because these children often experience peer problems, they may be more likely to engage in solitary play activities (Acevedo-Polakovich, 2005). Media use may be such an activity, regardless of its content.

Comparing Television and Game Use

Given the substantial differences between television viewing and game playing, we examined whether the relationship between media exposure and ADHD-related behaviors differed by medium. Overall, our results suggest that there are minimal differences between television viewing and gaming. The one lone difference indicated that the selection effect of ADHD-related behaviors on overall media use was only present for game playing. In other words, while ADHD-related behaviors predicted an increase in game playing among the teens in our sample, it did not alter general amounts of television viewing. Although it is speculation at this point, this specific effect of ADHD-related behaviors on overall game use may be due to the higher activity and interactivity that is characteristic of game playing as compared to television viewing. Television viewing is generally a 'lean-back' activity in which the viewer merely is an observer (Klimmt et al., 2009; Nakatsu et al., 2005). In contrast, in game playing, the player has to act for things to happen on the screen (i.e., higher activity) and becomes part of the virtual world (i.e., higher interactivity). Given that adolescents with high ADHD-related behaviors are believed to be under-aroused and therefore seek out stimulating activities, gaming may be an especially attractive activity for them due to this higher activity and interactivity. Television viewing in itself may be a less attractive activity, unless the content is exciting. Thus, although games in general may be attractive for adolescents with increased ADHD-related behaviors, for television the content (i.e., violent) may be the determining factor. This calls for future studies examining the role of activity and interactivity level in explaining the effect of ADHD-related behaviors on television and game preferences.

Gender and Age Differences

Empirical literature thus far suggests that gender and age may moderate the media-ADHD relationship. As such, in addition to testing whether medium may moderate relationships, we also asked whether gender and age may act as moderators. Somewhat surprisingly, we found no differences by gender. The relationships between media (overall and violent) and ADHD-related behaviors are the same for both boys and girls in our sample. This contrasts findings from a recent meta-analysis (Nikkelen et al., 2014) as well as a recent cross-sectional study among young children (Nikkelen et al., 2015) – both of which suggested that effects may be stronger for boys when compared to girls. The reason for this discrepancy is unclear, although it may be a function of age. Specifically, the majority of studies included in the meta-analysis were conducted among children in early or middle childhood, and the cross-sectional study noted above has focused on young children (e.g., ages 3-7 years old). It is possible that gender

differences occur earlier in age, and that in adolescence, these differences are no longer as apparent. A follow-up study in which a broader age range is investigated would certainly help to clarify whether the gender differences found in previous studies are contingent upon age.

As with gender, we did not find a moderating effect of age in the longitudinal relationships between media use and ADHD-related behaviors. Again, this was in contrast to what may be expected based on research showing that developmental and behavioral changes during adolescence are greatest at the start of adolescence (Crone & Dahl, 2012). On the one hand, it may be that these developmental changes simply do not influence the media-ADHD relationship in particularly unique ways. On the other hand, the lack of moderation may reflect the relatively narrow age-range of our participants. In this study, participants were between 10 and 14 years of age at study onset. Developmental differences may be more apparent if more diverse age groups (e.g., 10-12 years versus 16-18 years) were investigated. Future studies including larger age ranges are therefore needed.

Implications and Directions for Future Research

Our findings offer several important implications and directions for future research. Perhaps most important, our results indicate that ADHD-related behavior are not merely a *consequence* of violent media use but also a *cause*. This reciprocity suggests a reinforcing spiral effect (Slater, 2007), creating a negative cycle between violent media use and ADHD-related behaviors. As such, solely studying the effect of media use on ADHD-related behaviors provides a limited view of the relationship, especially since adolescents are active and willful users of media. Instead, to be able to truly understand the association between media use and ADHD-related behaviors, the dynamic process between the two should be taken into account. That said, as one of the first studies to examine the reciprocity between media use and ADHD-related behaviors, it is crucial that researchers work to replicate these findings – particularly in light of the fact that the effects uncovered in this study were not consistent across waves. Future longitudinal studies which measure both media use and ADHD-related behaviors at multiple time points with different samples will provide much needed information on the replicability and robustness of these findings.

Second, this study provided important evidence that the relationship between media use and ADHD-related behaviors is dependent on media content. All too often, studies focus exclusively on the mere amount of overall media use as opposed to delineating media use by content type, which obscures the true picture (Valkenburg & Peter, 2013b). In the current study, we see that violent

media use seems to be the explanatory variable – not general media use. We suspect that this relationship has to do with the arousal eliciting effect of violent media content, however, future studies that are not only sensitive to different content types but also attempt to test the causal mechanisms to explain this relationship are certainly warranted. For example, future studies may focus on other content that can be considered arousing (i.e., action-adventure shows/games) to examine whether it is the violence per se that relates to ADHD-related behaviors, or whether it is due to other aspects of this content (e.g., the action or the excitement).

Further, our findings highlight that it is worthwhile to consider how the medium may influence the media use-ADHD relationship. Thus far, the majority of existing studies have not separated television viewing and video game play instead opting for a more global approach. Although media format was not a particularly prominent moderator in our models, the differences in the media selection between television and video game suggest that a more granular approach in which media format is also considered in future analytic models is warranted. This means not only comparing different forms of media, but also thinking through how and why different ways of being involved with media may influence relationships between media use and ADHD-related behaviors. For example, it is possible that different methods of playing a video game (i.e., whether the child controls the game using a touchscreen, a controller, a keyboard, or using one's body as a controller) may lead to various degrees of experienced activity and interactivity (e.g., Bianchi-Berthouze, Kim, & Patel, 2007; Lindley, Le Couteur, & Berthouze, 2008). Consequently, this may lead to differences in how attractive the game is for adolescents with high ADHD-related behaviors.

Lastly, our findings also have important practical implications. Currently, commonly applied methods in the treatment of ADHD symptoms include, for example, stimulant drug therapy, dietary changes, behavioral training and parental guidance (Tarver, Daley, & Sayal, 2014). Monitoring and mediating children's media use are not typically part of such treatments, although adolescents on average spend more than five hours per day using television or games (Rideout et al., 2010). Our findings show that it may be worthwhile to consider adolescents' media use, especially their violent media use, in the prevention and treatment of ADHD-related behaviors. Since it seems that there is a reinforcing spiral effect of violent media use and ADHD-related behaviors, breaking this cycle could be an effective way of reducing adolescent's behavioral problems. Compared to stimulant drug therapy, mediation of adolescents' media use may be a non-invasive, easy to implement component in the treatment of ADHD-related behaviors.

Conclusion

In all, this study provides a nuanced view on the relationship between adolescents' media use and ADHD-related behaviors. By investigating reciprocal causal relationships between media use and ADHD-related behaviors, as well as paying careful attention to the role of media format, media content, gender, and age, this study is among the first to take a detailed look at whether a media effects or media selection perspective best explains the relationship between these variables. From a practical perspective, these findings indicate that it is important to monitor adolescents' violent media use, as this can be a cause and a consequence of elevated ADHD-related behaviors.

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