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

Nikkelen, S.W.C.

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Recent decades have witnessed an increasing concern that excessive use of entertainment media (i.e., television programs and games) may elicit ADHD-related behaviors in children and adolescents. However, the existing empirical research has not yet resulted in a clear picture of this association. The goal of this dissertation is therefore to provide a detailed understanding of the association between media use and ADHD-related behaviors. This dissertation consists of three parts. The first part aims to describe differences in media use associated with ADHD-related behaviors. In the second part, the role of individual difference factors in the media-ADHD relationship are examined. The third part examines the causal direction of the media-ADHD relationship. The findings of this dissertation may help inform public concerns and offer practical insights to healthcare professionals and parents.

The role of media entertainment in children's and adolescents' ADHD-related behaviors



Sanne W.C. Nikkelen

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A Reason for Concern?

Sanne Wilhelmina Cornelia Nikkelen

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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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Faculteit der Maatschappij- en Gedragwetenschappen

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# General introduction

More than ever, today's children are growing up in a highly competitive and performance-oriented society. As a natural consequence, those children with developmental problems stand out from their peers and are of particular concern. One developmental disorder that has come under increased scrutiny is attention-deficit/hyperactivity disorder (ADHD). ADHD is characterized as a cluster of three main symptom behaviors (American Psychiatric Association, 2013): inattention (i.e., problems staying concentrated, being distracted easily), hyperactivity (i.e., being restless, fidgety), and impulsivity (i.e., problems in inhibiting inappropriate behavior or responses, not thinking before acting). With a prevalence ranging from 5.0 to 7.1% (Willcutt, 2012), it is one of the most common childhood developmental disorders, and often continues in adulthood (Faraone, Biederman, & Mick, 2006). The behavior problems of children with ADHD are particularly apparent in the classroom, where children are required to remain seated and focused for continuous periods of time. Not surprisingly, children with ADHD generally have lower academic performance than their typically developing peers (Loe & Feldman, 2007). However, these children also face problems in other domains. For example, ADHD is associated with significant peer problems (e.g., they have less friends and are less liked by their peers, Wehmeier, Schacht, & Barkley, 2010) and have a higher risk of later substance abuse (Bidwell, Henry, Willcutt, Kinnear, & Ito, 2014). As a result of these and other challenges, ADHD is associated with high economic costs for society. To illustrate, a recent report using the Netherlands as an example (Le et al., 2014) estimated an annual national cost of €1,041 million to €1,529 million that can be attributed to ADHD (e.g., including costs related to education, healthcare, and social services). ADHD is clearly of great concern to parents, teachers, healthcare professionals, as well as society at large.

Against common presumptions and worries that ADHD diagnosis rates have been rising, recent research has shown that the prevalence of ADHD has remained stable in the past decades (Polanczyk, Willcutt, Salum, Kieling, & Rohde, 2014). There has been, however, a growing awareness of ADHD and an alarming increase in the prescription of drugs to treat ADHD symptoms (Mehlkopf, Houweling, Heerdink, & Penning-van Beest, 2012), which has fueled the scientific and public interest in the disorder. In particular, the past decades have witnessed an increasing concern that excessive use of entertainment media (i.e., television and video games) may elicit ADHD symptoms in children. Due to and synchronous with these concerns, research on the potential relationship between entertainment media use and ADHD has accumulated. The results of some of these studies have been extensively covered in the popular press, with cautionary news headlines such as, *'Pants-wearing sponge blamed for kid's poor attention spans'* (Rubin, 2011, December 9), *'Television kids develop attention problems, study claims'*

(Green, 2012, February 3), and *'Children who play video games for two hours a day may 'DOUBLE risk of getting ADHD'* (Daily Mail Reporter, 2010, July 8). However, in contrast to what these headlines may suggest, studies on the media-ADHD relationship have not yet resulted in a clear picture of this association. It is still unknown, for example, what type of media (in terms of form and content) may be associated with ADHD, whether such relationships are the same for all children, and the direction of the relationship between media use and ADHD. It is therefore perhaps not surprising that recent literature reviews within the field of child psychology and psychiatry do not consider the role of children's entertainment media use in the development of children's ADHD symptoms (Tarver, Daley, & Sayal, 2014; Thapar, Cooper, Eyre, & Langley, 2013). However, given the importance of media in children's lives today, it is crucial that researchers work to disentangle the relationship between media use and ADHD. The focus of this dissertation is therefore to provide a nuanced perspective on this relationship in children and adolescents. Insights into the role of media use in ADHD may guide future non-medical interventions aimed at reducing ADHD symptoms. After all, strategies to regulate children's media use may be less pervasive than treatment with drugs, and may be relatively easily implemented.

### **Conceptualization of ADHD**

Although ADHD traditionally represents a clinical diagnostic disorder, with a clear cut-off between children with and without the disorder, ADHD is measured as a continuous variable throughout the studies in this dissertation. There has been an increasing trend in psychology towards conceptualizing several conditions, including ADHD, on a spectrum rather than as qualitatively distinct, categorical disorders (e.g., Krueger & Bezdjian, 2009). In this view, the behaviors symptomatic of ADHD are distributed continuously among the general population, ranging from no to extreme problem behaviors (Larsson, Anckarsater, Råstam, Chang, & Lichtenstein, 2012; Levy, Hay, McStephen, Wood, & Waldman, 1997; Lubke, Hudziak, Derks, van Bijsterveldt, & Boomsma, 2009). As such, the term 'ADHD-related behaviors' is used throughout this dissertation. A benefit of conceptualizing ADHD in this way is that it enables for research and practice which is generalizable to the entire population of children, and not just to a small group of children showing extreme behavior problems.

### **Potential Roles of Media use in Children's ADHD-Related Behaviors**

Arguments for why media use and ADHD-related behaviors are likely to be associated center mainly around children's arousal functioning. Arousal is an excitatory bodily state which fluctuates on a moment-to-moment basis, in

response to environmental stimulations and one's own behavior (Humphreys & Revelle, 1984). It is generally accepted that there is an 'optimal' level of arousal, which differs between individuals (optimal stimulation theory, Zentall & Zentall, 1983). Arousal levels that are too high (associated with tension, excitement) and too low (associated with dullness, boredom) are deemed unpleasant states and, to a certain extent, people can adjust their behavior accordingly (e.g., one may go to a quieter area when a place is too noisy or busy). It is frequently argued that the behaviors characteristic of ADHD are caused by low baseline arousal. For example, because a certain level of arousal is needed to remain focused, low arousal can lead to attention problems (Nigg, 2006). Moreover, because low arousal feels unpleasant, it may lead to hyperactive, impulsive behavior, which can elevate arousal to a more pleasant level (White, 1999).

When applying this arousal theory to media use, there are two main roles media use may play in children's ADHD-related behaviors. First, from a media effects perspective, media use may contribute to the development of ADHD-related behaviors by affecting children's arousal functioning. For example, television programs and videogames can be highly exciting and elicit increased arousal levels in the child (Anderson & Bushman, 2001; Fleming & Rickwood, 2001). With repeated exposure, children may become used to this frequent stimulation, and their responsiveness to this stimulation may decrease (i.e., a desensitization effect, Ballard, Hamby, Panee, & Nivens, 2006). As a consequence of this desensitization process, children may become under-aroused without the presence of exciting stimuli. As under-arousal is believed to underlie the behaviors associated with ADHD, children who frequently use exciting media may thus display ADHD-related behaviors in situations that are less exciting (i.e., in the classroom). As an alternative to this arousal-focused theory, it has been argued that media use displaces activities that are believed to be more cognitively stimulating than television viewing or game playing (e.g., educational play activities), thereby delaying cognitive development and increasing the likelihood that children develop ADHD-related behaviors (Christakis, 2009; Zimmerman & Christakis, 2007).

Second, from a media selection perspective, ADHD-related behaviors may influence specific media behaviors or preferences. Because of the low arousal levels characteristic of ADHD, children with high ADHD-related behaviors may be more drawn to entertainment media, and particularly to exciting content, to elevate their arousal to a more pleasant level (Miller et al., 2007). If this is true, media use may serve as a form of self-regulatory behavior. Alternatively, children with high ADHD-related behaviors may be likely to turn to media due to the social problems they often face. For example, because ADHD-related behaviors

are associated with frequent parent-child conflict, parents of children with high ADHD-related behaviors may be more permissive of their child's media use in order to enjoy some time without conflict and discussion (Acevedo-Polakovich, 2005). In addition, children with high ADHD-related behaviors may engage in more solitary play (like media use) as they often experience peer difficulties (Wehmeier et al., 2010).

### **Dissertation Aims**

The aims of this dissertation are guided by the Differential Susceptibility to Media effects Model (DSMM, Valkenburg & Peter, 2013). The DSMM provides a comprehensive framework for understanding how and when media effects occur. It includes four basic premises: (1) media effects on behavior are indirect and mediated by media responses, such as arousal, (2) media use and effects are conditional on individual susceptibility factors, like parenting behavior, (3) individual susceptibility factors concurrently influence use and effect of media, and (4) media-behavior relationships are transactional. Taking the DSMM as a starting point, three important gaps in previous media-ADHD studies can be identified, which are addressed in this dissertation. First of all, to be able to examine the premises of the DSMM, it is essential to first have a thorough understanding of the specific media use behaviors that are associated with ADHD-related behaviors, that is, what media children use and how they respond when using it. This is unclear from previous literature. For example, although it is often hypothesized that children with high ADHD-related behaviors use more media in general and are more attracted to violent content (e.g., Miller et al., 2007), empirical studies show inconsistent results (i.e., some confirming and some disproving these expectations, also see Kirkorian, Wartella, & Anderson, 2008; Schmidt & Vandewater, 2008). In addition, little is known about whether ADHD-related behaviors are associated with differences in media responses. For example, it is plausible that ADHD-related behaviors are associated with differences in children's attention and arousal level when using media. This, however, has rarely been studied. The first aim of this dissertation is therefore to describe the specific media use behaviors associated with ADHD-related behaviors. By doing so, a clear foundation is built for further research looking at this relationship in more detail.

Second, there has been little focus on individual susceptibility in the media-ADHD relationship. The DSMM proposes that the relationship between media use and behavior is not universal. Instead, individual difference factors can directly influence media use (i.e., what media a child is exposed to) and can strengthen or weaken the effect of media use on behavior. Hence, it is crucial to incorporate

child and social context factors when examining media-behavior relationships. Applying the propositions of the DSMM to the media-ADHD relationship, individual difference factors may play two roles in this association. First, certain children may be more likely than others to use developmentally inappropriate media, which in turn may elicit ADHD-related behaviors. Second, the relationship between media use and ADHD-related behaviors may be stronger for particular children. Therefore, the second aim of this dissertation is to examine individual susceptibility in the relation between media use and ADHD-related behaviors. Specifically, this dissertation will focus on two types of susceptibility factors as distinguished in the DSMM: dispositional susceptibility (i.e., susceptibility due to dispositional factors, like children's genetic make-up) and social susceptibility (i.e., susceptibility caused by factors in children's social environment, like parent behavior).

A third gap in the current literature is that little is known about causality in the media-ADHD relation. As aforementioned, there is argumentation for why media use may elicit ADHD-related behaviors, as well as for why ADHD-related behaviors may cause differences in media use. As proposed by the DSMM as well as by the reinforcing spirals model (Slater, 2007), both processes may work simultaneously. However, most existing longitudinal studies on the media-ADHD relationship have been conducted from a media effects perspective and did not consider these reciprocal relationships. Those that did have resulted in different conclusions concerning causality (Gentile, Swing, Lim, & Khoo, 2012; Johnson, Cohen, Kasen, & Brook, 2007; Stevens, Barnard-Brak, & To, 2009). Therefore, the third and final aim of this dissertation is to examine the causal direction in the media-ADHD relationship.

## **Dissertation Outline**

Consistent with the three aims, this dissertation consists of three parts with a total of five empirical studies. The following sections summarize the five studies. All studies are either published, under revision, or submitted for publication. The content of each chapter in this dissertation is equal to the published or submitted studies. The studies are self-contained, each chapter therefore has its own abstract, introduction, discussion, and reference list and can be read individually. After presenting the individual chapters, the dissertation concludes with a general discussion.

### **Part 1: Examining the Specific Media Use Behaviors Associated with ADHD-Related Behaviors**

The first part of this dissertation addresses the first aim: describing differences

in media use associated with ADHD-related behaviors. This is accomplished through a meta-analysis summarizing existing empirical studies on the relationship between media use and ADHD-related behaviors (Chapter 1) and a television diary study examining what content young children watch and how they respond to that content, in relationship to their ADHD-related behaviors (Chapter 2).

### *Chapter 1: Meta-analysis*

Chapter 1 reports on a quantitative meta-analysis of studies investigating the relationship between screen media use and ADHD-related behaviors in children and adolescents up to the age of 18. Within this meta-analysis, four outcomes were distinguished: inattentiveness, hyperactivity, impulsivity, and composite ADHD (i.e., combined measures of inattentiveness, hyperactivity, and impulsivity). The main goal of this study was to calculate an average effect size of the relationship between media use and these four outcomes. In addition, three possible moderators were examined: media content (i.e., violent content, fast pacing, and overall time spent using media), media type (i.e., television, video games), children's age, and children's sex. In total, this meta-analysis included 45 empirical studies. A final goal of this chapter was to identify important gaps in the current body of literature.

### *Chapter 2: A television diary study of television use and responses*

Chapter 2 presents a detailed look into young children's (ages 3-7) television use, in relationship to their ADHD-related behaviors. First of all, this study examined the association between children's ADHD-related behaviors and their amount of television viewing in general and specific content viewing (i.e., violent/scary and educational). Furthermore, it investigated children's arousal and attention responses when viewing television in general, and when viewing specific content. Finally, it tested sex differences in all aforementioned relationships. To examine these relations, this study combined a survey with a comprehensive four-day television diary, filled out by children's parents ( $N = 865$ ). The television diary enabled a close examination of what content children actually watched and how they responded to that content.

## **Part 2: Factors Influencing Susceptibility to Media Use and the Media-ADHD Relationship**

The second part addresses the second aim of this dissertation: examining the role of individual difference factors in the media-ADHD relationship. This part consists of two chapters, each examining a different type of individual susceptibility

distinguished in the DSMM (Valkenburg & Peter, 2013). Chapter 3 focuses on the role of genetic variation (i.e., dispositional susceptibility), while Chapter 4 focuses on the role of parental mediation practices (i.e., social susceptibility).

#### *Chapter 3: Genetic disposition*

Chapter 3 investigates the role of children's genetic disposition in the relationship between violent media use and children's ADHD-related behaviors. In line with the premises of DSMM, this study examined whether genetic disposition is directly related to violent media use, and thereby indirectly related to ADHD-related behaviors, and whether it moderates the relationship between violent media use and ADHD-related behaviors. To answer these questions, genetic data were combined with parent-report surveys of 1,612 children (5-9 years). This study focused on a specific gene variant that has repeatedly been linked to ADHD: the 5-HTTLPR polymorphism.

#### *Chapter 4: Parental media mediation*

Chapter 4 focuses on the role of parental media mediation (i.e., the way parents handle their child's media use) in the relationship between media violence and ADHD-related behaviors in early adolescents (10-14 years). This survey study ( $N = 1,017$ ) distinguished two commonly studied mediation strategies, namely restrictive mediation (i.e., rule-setting) and active mediation (discussing media content), and how these strategies are communicated to the adolescent: in a controlling (i.e., using punishment, threat, or shame), inconsistent (i.e., being alternately strict and permissive), or autonomy-supportive (i.e., being encouraging and considerate of the child's perspective) way. Two models were tested. For restrictive mediation, this study examined whether parents' restrictive mediation styles directly related to adolescents' violent media use, and indirectly related to adolescents' ADHD-related behaviors via violent media use. For active mediation, this study investigated whether parents' active mediation style moderated the relationship between violent media use and ADHD-related behaviors.

### **Part 3: Directions of Effect**

The last part of this dissertation, consisting of one chapter (Chapter 5), addresses the third aim of this dissertation: to examine the causal direction of the media-ADHD relationship.

#### *Chapter 5: Examining reciprocity*

The empirical studies described in the previous chapters all employed a correlational design. As such, an association between ADHD-related behaviors

and media use could be established, but the question of causality remains. Also from previous literature, little can be concluded about whether a relationship over time exists and what the causal direction of this relationship is. The fifth chapter of this dissertation therefore aimed to extend current knowledge about the causal direction in the media-ADHD association by conducting a three-wave longitudinal study (with one-year intervals) among 1,032 adolescents (10-14 years old). Next to examining causal direction, this study examined content differences (i.e., overall media use versus violent media use), format differences (i.e., television versus games), and sex and age differences.

### **General Discussion**

The general discussion will provide an overview of the main findings and the general conclusions of this dissertation. Further, it will present the implications of the findings and several directions for future research.

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# Chapter 1

## **Media use and ADHD-related behaviors in children and adolescents: A meta-analysis**

### **Abstract**

There are several theoretical reasons to believe that media use might be related to attention-deficit/hyperactivity disorder (ADHD) or ADHD-related behaviors (i.e., attention problems, hyperactivity, and impulsivity). Although studies into the media-ADHD relationship have accumulated, they have yielded inconsistent results. Therefore, we still do not know whether children's media use and ADHD-related behaviors are related, and if so, under which conditions. To fill this gap in the literature, we first identified six different hypotheses that may explain why media use in general, and viewing fast-paced or violent media content might be related to one or more ADHD-related behaviors. Subsequently, we conducted a meta-analysis of 45 empirical studies investigating the relationship between media use and ADHD-related behaviors in children and adolescents. Our results indicated a small significant relationship between media use and ADHD-related behaviors ( $r^+ = .12$ ). Finally, we identified several specific gaps in the existing literature and presented five crucial directions for future research.

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In the past four decades, children's media entertainment (e.g., cartoons, TV shows, and computer games) has changed significantly. It has become more fast-paced, violent, and arousing (Allen, Livingstone, & Reiner, 1998; Bushman, Jamieson, Weitz, & Romer, 2013; Koolstra, van Zanten, Lucassen, & Ishaak, 2004), and it has become abundantly accessible to ever younger children. These same four decades have also witnessed a significant increase in the diagnosis rate of attention-deficit/hyperactivity disorder (ADHD; Akinbami, Liu, Pastor, & Reuben, 2011; Kelleher, McInerney, Gardner, Childs, & Wasserman, 2000; Visser et al., 2014). ADHD is a behavioral disorder characterized by a cluster of three symptoms: attention problems, hyperactivity, and impulsivity (*Diagnostic and Statistical Manual of Mental Disorders 5th ed. [DSM-V]*, American Psychiatric Association, 2013). Although ADHD traditionally has been viewed as a qualitatively distinct diagnostic category, nowadays it is often conceptualized as an extreme end on a continuum of behaviors (Larsson, Anckarsater, Råstam, Chang, & Lichtenstein, 2012; Lubke, Hudziak, Derks, van Blijsterveldt, & Boomsma, 2009). In this article, we use the term *ADHD-related behaviors* to refer to this continuous distribution of attention problems, hyperactivity, and impulsivity among the general population of children and adolescents.

The parallel between changes occurring in children's media environment and ADHD diagnosis rates have led to a concern among some authors that use of media entertainment may influence ADHD-related behaviors (e.g., Christakis, 2009; Jensen et al., 1997; Nigg, 2006; Sigman, 2007). Although studies into the relationship between children's media use and ADHD-related behaviors have accumulated, they have yielded mixed results (also see Kirkorian, Wartella, & Anderson, 2008; Schmidt & Vandewater, 2008). It is essential to gain more understanding of the media-ADHD relationship in order to design adequate prevention and intervention strategies aimed at children displaying behavioral problems. To date, no attempt has been made to integrate the inconsistent findings in the current literature using meta-analysis. To fill this gap, we conducted a meta-analysis of studies investigating the relationship between the use of screen entertainment media (i.e., television viewing and video game playing) and ADHD-related behaviors in children or adolescents under the age of 18.

For this meta-analysis, we systematically collected all cross-sectional, longitudinal, and experimental studies examining the relationship between screen entertainment media use and ADHD-related behaviors. The aim was to calculate an average correlation for the relationship between screen entertainment media use and ADHD-related behaviors. In addition, we examined three factors that might influence the strength of this relation: *media content* (i.e., violent media, fast-paced media, overall media use), *media types* (i.e., television vs. video games),

and *child characteristics* (i.e., age, sex).

### **Media Content**

Several hypotheses have been put forward to explain how media use could induce ADHD-related behaviors. Some of these hypotheses attribute this effect to its violent content (Zimmerman & Christakis, 2007). Other hypotheses attribute this effect to the fast pace of entertainment media (i.e., the frequent use of cuts, edits, and fast character movement; Christakis, 2009; Christakis, Zimmerman, DiGiuseppe, & McCarty, 2004; Geist & Gibson, 2000; Halpern, 1975; Jensen et al., 1997; Landhuis, Poulton, Welch, & Hancox, 2007; Levine & Waite, 2000), or to the overall amount of time children spent consuming media (Christakis, 2009; Zimmerman & Christakis, 2007). Therefore, in this meta-analysis, we included all studies investigating the effect of either violent, fast-paced, or overall screen media use on ADHD-related behaviors. Comparing the strengths of these three relationships allowed us to single out whether a potential media effect on ADHD-related behaviors should be attributed to the overall time spent with media, or to fast-paced or violent media.

**Violent content.** Television programs, movies, and video games frequently contain acts of physical violence (Wilson et al., 2002). Two hypotheses may explain why media violence may lead to ADHD-related behaviors. A first hypothesis, which we have named the *violence-induced script hypothesis*, argues that because violence is characterized by impulsive behavior (i.e., no inhibition of antisocial behavior), exposure to such violent acts may activate a behavioral script of poor self-control (Anderson & Bushman, 2001; Hummer et al., 2010). Activation of such a script, in turn, may result in attention problems, hyperactivity, or impulsivity, which are assumed to result from poor self-control (Barkley, 1997a).

A second hypothesis, which we have named the *violence-induced arousal-habituation hypothesis*, states that violent media content causes ADHD-related behaviors by its effect on children's arousal system. Violent media content can induce intense arousal in children (Bushman & Huesmann, 2006; Fleming & Rickwood, 2001). However, after repeated exposure, children may get desensitized to media violence, which means that they gradually experience less induced arousal to the same violent media portrayals (Ballard, Hamby, Panee, & Nivens, 2006). As a result of this desensitization process, children may start to experience a state of underarousal in less stimulating environments. Underarousal, in turn, can cause attention problems, hyperactivity, and impulsivity (Nigg, 2006; White, 1999).

**Fast pace.** The literature has revealed two hypotheses explaining the effects of fast-paced media on the development of ADHD-related behaviors. A first

hypothesis, which we named the *scan-and-shift hypothesis*, states that fast-paced media, by the frequent use of cuts and edits, teach the child an attentional style of scanning and shifting (Jensen et al., 1997). Such an attentional style may hinder the child in tasks that require sustained attention, such as doing schoolwork. A second hypothesis, which we named the *fast-pace arousal-habituation hypothesis*, states that the fast pace of entertainment media may increase arousal by triggering repeated attention shifts in the user (Lang, Zhou, Schwartz, Bolls, & Potter, 2000). After frequent exposure to fast-paced media, children might get habituated to this arousal lift, thereby decreasing their baseline arousal level. As with violent media use, low baseline arousal may cause ADHD-related behaviors.

**Overall media use.** Two additional hypotheses do not attribute the effect of media use on ADHD-related behaviors to specific features of media but rather to the large amount of time children spend using media. The *displacement hypothesis* states that frequent use of screen entertainment media might displace activities that are thought to stimulate cognitive abilities more than screen entertainment media, such as imaginative play (Christakis, 2009; Zimmerman & Christakis, 2007). A second hypothesis, which we refer to as the *impaired-language development hypothesis*, states that excessive use of screen entertainment media hinders language development because it mainly relies on visual processing, and uses adult-like language that is not attuned to the child's cognitive ability (Nigg, 2006; Zimmerman & Christakis, 2007). Language skills are assumed to facilitate self-regulation in children by allowing for reflection on and directing of their behavior (Beaver, Delisi, Vaughn, Wright, & Boutwell, 2008; Gallagher, 1999). The presumed media-induced lack of language development is assumed to disrupt the consolidation of self-regulation (Jensen et al., 1997), leading to ADHD-related behaviors.

## Media Types

Both video game playing and television viewing have been argued to induce ADHD-related behaviors through the mechanisms we described (Acevedo-Polakovich, 2005; Christakis, 2009). These two media activities, however, are quite different in nature, which may lead to differences in the strength of their effects. First, unlike television shows and movies, video games allow for interactivity; the player is in part responsible for the way the game unfolds (Vorderer, 2000). Second, whereas video game playing is typically a primary activity, television viewing is often used as a secondary activity (Carnagey & Anderson, 2004). Finally, identification with a media character, if any, may be higher in video game playing, because the player is in control of the character (Carnagey & Anderson, 2004). To investigate whether the correlation between media use and ADHD-related

behaviors differed between studies measuring television viewing and those measuring video game playing, we included both types of studies in this meta-analysis.

### **Child Characteristics**

**Age differences.** Compared with older children and adolescents, younger children might be more strongly affected by media use. Children in early childhood have been shown to be particularly susceptible to environmental influences (Knudsen, 2004; Mundkur, 2005; Uylings, 2006), including media influences (Christakis, 2009; Valkenburg & Peter, 2013a). In addition, young children (younger than about age 7) are not yet able to make a clear distinction between fantasy and reality in the media (Valkenburg & Cantor, 2001). As a result, they have difficulty making sense of what they see on the screen and distinguishing it from the “real” world, which may lead to stronger media effects. Moreover, young children are not yet able to reassure themselves effectively when confronted with violent media content (Cantor, 2009), and they are less able than older children to regulate their arousal levels when watching violent and action oriented media (Gross & Thompson, 2007). Inspecting the effect of age was one aim of this meta-analysis. We expected that the correlation between media use and ADHD-related behaviors would decrease with age.

**Sex differences.** Previous research has shown that, compared with girls, boys more often exhibit ADHD-related behaviors (Gershon & Gershon, 2002; Lavigne, LeBailly, Hopkins, Gouze, & Binns, 2009). Boys also spend more time using media than girls (Rideout, Foehr, & Roberts, 2010), and are more attracted to violent and action-packed media (Cantor, 1998; Olson et al., 2007; Valkenburg & Janssen, 1999). However, these observed sex differences in media preferences and ADHD-related behaviors do not necessarily imply that the effect of media use on ADHD-related behaviors is stronger for boys than for girls. For example, although boys are generally more aggressive than girls (Card, Stucky, Sawalani, & Little, 2008) and have a stronger preference for media violence, one meta-analysis revealed larger media violence effects on aggression in males (Paik & Comstock, 1994), whereas other meta-analyses showed no sex differences (Anderson et al., 2010; Anderson & Bushman, 2001). Sex differences in media-induced effects on ADHD-related behaviors did not receive much attention in earlier research, and to investigate such differences was another aim of the present meta-analysis.

### **Outcome Variables**

The available empirical studies differ in their conceptual and operational definitions of ADHD and ADHD-related behaviors. In this meta-analysis, we

included studies focusing on clinically diagnosed ADHD as well as studies using continuous measures of the three ADHD-related behaviors (i.e., attention problems, hyperactivity, and impulsivity). We define *attention problems* as children's inability to focus their attention (i.e., being easily distracted), which is important for organizing and completing a task. *Hyperactivity* refers to excessive physical activity (i.e., being continuously in motion). *Impulsivity* is defined as the inability to control immediate action (i.e., not thinking before acting; Barkley, 1997b; Nigg, 2006).

Most studies examining the media-ADHD relationship include a composite measure of attention problems, hyperactivity, and impulsivity, without distinguishing among the three behaviors. Although the three behaviors often co-occur, children may also predominantly exhibit one or two of them (American Psychiatric Association, 2013). Moreover, media effects may differ for each of the three ADHD-related behaviors. In this meta-analysis, we therefore focused on the relationship between media use and composite measures of ADHD-related behaviors, as well as on the relationship between media use and attention problems, hyperactivity, and impulsivity separately.

## Method

### Search Strategies

Relevant studies for this meta-analysis were obtained using a three-step approach. First, we searched the Web of Science and PsycINFO databases using the following search terms: “(*media* or *TV* or *television* or *game*\*)” and “(*ADHD* or *attention*\* or *hyperactiv*\* or *impulsiv*\*)”. This search covered journal articles and doctoral dissertations from the year each database started until September 2013. Second, we examined the reference sections of studies related to the subject of media use and ADHD-related behaviors for additional citations. Third, to reduce potential publication bias, we contacted all corresponding authors of included studies to request for additional unpublished data. These three steps generated a sample of 50 studies that met the inclusion criteria described in the following section.

### Inclusion and Exclusion Criteria

Studies had to meet three criteria to be included in this meta-analysis. First, they required the inclusion of a measure or a manipulation of media violence, media pacing, or overall media use. Media violence referred to television, movies, or video games containing physical actions that kill or injure living beings. Media pacing pertained to the frequency of use of cuts, edits or scene changes.

Overall media use referred to the overall amount of time spent viewing television (including movies) or playing video games on any platform (e.g., in hours per week). The literature search also yielded several studies that distinguished other categories of media content (e.g., educational and non-educational media, or child-directed and adult-directed media). Because there were too few studies available for these other categorizations to conduct reliable analyses, these were not included in this meta-analysis.

Second, studies had to use a measure of ADHD-related behaviors. A first type of studies included in the meta-analyses consisted of samples in which a group of children who were clinically diagnosed with ADHD was compared with a control group not diagnosed with ADHD. A second type of studies included non-clinical samples, in which measures of media use were related to measures of attention problems, hyperactivity, or impulsivity, or a composite measure of these dimensions (which we refer to as *ADHD composite*). Studies using survey measures or observational measures of ADHD-related behaviors were included when items in the measures were consistent with the diagnostic criteria of ADHD in the *DSM-V*. Studies using survey measures that included items measuring aggressive behavior were excluded from this meta-analysis (Stevens & Mulsow, 2006). For studies using experimental measures (e.g., computerized tasks) that could not be evaluated using these criteria, earlier empirical evidence of an association between the particular measure and the *DSM-V* criteria was required.

Third, we only included studies with child participants younger than 18 years of age. The relation between media use and adult ADHD was beyond the scope of this project. Moreover, although the literature search yielded a handful of studies with adult participants, these were too few to be included in our meta-analysis.

Of the 50 studies that met these three inclusion criteria, four studies were excluded because effect sizes could not be computed due to missing statistics, even after repeated efforts to contact the corresponding author (Barnard, 2009; Ebenegger et al., 2012; Mistry, Minkovitz, Strobino, & Borzekowski, 2007; Valdez et al., 2007). A rationale for exclusion of these studies is available from the first author. Finally, because the results of two studies were derived from the same sample (Christakis et al., 2004; Foster & Watkins, 2010), these studies counted as one study in our sample.<sup>1</sup> Our final sample thus included 45 studies.

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<sup>1</sup>A study by Christakis, Zimmerman, DiGiuseppe, and McCarthy (2004) was replicated in a 2010 study by Foster and Watkins, using the same dataset. Both studies only reported partial effect sizes. After contacting the authors of both papers, we received raw correlation coefficients of the authors of the 2010 paper. Therefore, this study is listed in Table 2, and not the original 2004 study.

## Measures of ADHD-Related Behaviors

The studies that were included in this meta-analysis showed large variability in the way ADHD-related behaviors were conceptualized and measured. Several studies included multiple measures for assessing ADHD-related behaviors, such as parent and self-report. Six studies included children who were clinically diagnosed with ADHD and a control group of children. The majority of the studies included a survey measure of ADHD-related behaviors filled out by one or multiple informants. Parent reports were most common ( $k = 28$ ), followed by teacher reports ( $k = 10$ ) and self-reports ( $k = 6$ ). The most common survey measures were subscales from the Child Behavior Checklist (CBCL; Achenbach, 2009) and the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997). A multitude of different survey measures were used in the other studies.

Seven studies in this meta-analysis included measures other than self-, parent-, or teacher-report measures to assess ADHD-related behaviors. One study (Kronenberger et al., 2005) used the Continuous Performance Task (CPT; Conners, 2000), one study (Cooper, Uller, Pettifer, & Stolc, 2009) used the Attentional Networks Test (ANT; Rueda et al., 2004), two studies (Anderson, Levin, & Lorch, 1977; Gadberry, 1980) used the Matching Familiar Figures Test (MFFT; Kagan, Rosman, Day, Albert, & Philips, 1964), and a fifth study included actigraphy to measure the amount of movement displayed by the child during a certain time period (Miller et al., 2007). The two remaining studies used coded observations during free-play (Tower, Singer, Singer, & Biggs, 1979) or during normal class periods (Levine & Waite, 2000) to measure ADHD-related behaviors.

## Coding of Studies

The following variables were coded for each study: (a) *outcome* (i.e., attention problems, hyperactivity, impulsivity, or ADHD composite), (b) *measurement type* (i.e., standardized or unstandardized measure of ADHD), (c) *study design* (i.e., cross-sectional, longitudinal, or experimental), (d) *media type* (i.e., television or video games), (e) *media content* (i.e., violent content, fast-paced content, or overall media use), (f) *proportion of girls* in the sample, and (g) *mean age* of the sample (in years; in case of multiple data waves, age was coded as the mean age at the first wave).

Often, authors intended to measure one of the ADHD-related behaviors (e.g., attention problems), but included a scale or items of a scale that also tapped other dimensions (e.g., Landhuis et al., 2007; Swing, Gentile, Anderson, & Walsh, 2010; Zimmerman & Christakis, 2007). Consequently, such a measure does not solely reflect the intended behavior. This problem of conceptual contamination could bias the meta-analytic results. To avoid this potential bias, the first and

third author independently categorized each of the outcome measures used in the included studies into one of four categories: attention problems, hyperactivity, impulsivity, or ADHD composite using the diagnostic criteria of ADHD in the *DSM-V*. A measure covering two or three ADHD-related behaviors as described in the *DSM-V* (e.g., attention problems and hyperactivity), was rated as an ADHD composite measure. This rating process resulted in a satisfactorily inter-coder reliability (Cohen's  $\kappa = .76$ ). The two raters discussed rating disagreements to achieve a single rating for each measure. Studies including samples of children who were clinically diagnosed with ADHD were categorized as ADHD composite.

### Computation of Effect Sizes

Four data sets were constructed, one for each outcome variable. All data sets were analyzed using the Comprehensive Meta-Analysis (CMA) software. The effect size estimate used in the analyses was the Pearson product-moment correlation coefficient ( $r$ ). For studies that did not report correlation coefficients, we used other available statistics (e.g.,  $t$  tests) that were transformed to  $r$ s. In case of missing information (e.g., mean age of the study sample), we contacted the authors via e-mail. In cases where studies reported nonsignificant results without additional statistics available to calculate an effect size and the authors were unable to provide us with the data, we used the common and conservative method of ascribing the study a correlation of zero (Pigott, 1994). This was the case for two of the studies (Anderson & Maguire, 1978; Milich & Lorch, 1994).<sup>2</sup>

For studies that reported multiple effect sizes (e.g., separate correlations for television viewing and video game playing, or cross-sectional and longitudinal correlations), we used a shifting unit of analysis approach (Cooper, 1989). Each statistical test was coded as if it were an independent event. For example, if a study included separate correlations for overall media use and violent media use for both television and video games, four effect-size estimates were coded (i.e., for overall television viewing, violent television viewing, overall video game playing, and violent video game playing). For the overall effect, however, the four effect-size estimates were averaged so that the study provided only one effect-size estimate. Thus, the shifting unit of analysis retains as much data as possible without violating the independence assumption that underlies the validity of meta-analytic procedures.

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<sup>2</sup> There were 2 studies that reported non-significant results without reporting the actual effect size: one in the 'ADHD composite' dataset and one in the 'impulsivity' dataset. Removal of these studies did not change the meta-analytic results.

## Statistical Analyses

The analyses were conducted separately for each of the four outcome variables (i.e., attention problems, hyperactivity, impulsivity, and ADHD composite). Although there is no strict rule about the minimum number of effect sizes to include in a meta-analysis, performing a meta-analysis on a small number effect sizes increases the chance of second-order sampling error (Hunter & Schmidt, 2004). Due to the heterogeneity of the studies included in this meta-analysis, we only performed analyses when there were five or more independent effect size estimates available. All analyses were conducted using a random effects model, which allows for variation between the studies' effect sizes. This method is recommended when the included studies differ on several aspects (e.g., sample characteristics) and it allows one to generalize the result beyond the set of studies included in the meta-analysis (Borenstein, Hedges, Higgins, & Rothstein, 2009; Hunter & Schmidt, 2004).

For each outcome variable, we first examined the general relationship between media use and ADHD-related behaviors, without distinguishing among measurement type, media types, media content, or study design. Before conducting these analyses, we averaged dependent correlations (i.e., correlations that were calculated for the same sample of participants). This is considered a conservative method, resulting in wider confidence intervals upon calculation of the average effect size than if each dependent correlation was used separately in the analysis (Borenstein et al., 2009). Fisher  $z$ -transformation was applied to each correlation coefficient to normalize its distribution (Silver & Dunlap, 1987). Next, we calculated the average effect size for each outcome, which was transformed back to Pearson's  $r$  for interpretative purposes. This pooled estimate of  $r$  is denoted as  $r_p$ . Finally, we performed a  $Q$ -test (which has a chi-square distribution) for heterogeneity to examine differences between outcomes (Borenstein et al., 2009).

In a second step, we used multiple regression analysis to analyze all study characteristics simultaneously to account for possible covariance between studies. Age (i.e., mean age of the sample in years) and sex (i.e., proportion of girls in the sample) were entered as continuous variables. Measurement type (0 = *unstandardized*, 1 = *standardized*), media type (0 = *television*, 1 = *video games*), media content (0 = *overall*, 1 = *violent*) and study design (0 = *cross-sectional*, 1 = *longitudinal*) were entered as dichotomous variables. We excluded the categories "fast-paced" and "experimental" because, as we demonstrate later, too few independent effect sizes were available for these categories. The model was tested using restricted maximum likelihood. Again, Fisher  $z$ -transformation was first applied to each correlation coefficient.

In each analysis, we examined the presence of outliers by standardizing all effect sizes. An effect size was considered an outlier when the absolute value of its standardized score (i.e.,  $z$  value) was 2 or higher. In the multiple regression analysis, we used the Studentized residuals to detect outliers, again using the criterion  $z \geq 2$ . Outliers were removed step by step in each analysis. We conducted a sensitivity analysis to determine whether the meta-analytic results changed upon removal of these outliers.

### **Publication Bias Analyses**

To test for potential publication bias, we included four publication bias tests: (a) Orwin's fail-safe  $N$  test, (b) Begg and Mazumdar's rank correlation test, (c) Egger's regression test, and (d) Duval and Tweedie's trim and fill procedure. Orwin's fail-safe  $N$  test calculates the number of additional (i.e., unpublished) studies with a certain mean effect size that would result in an average effect size below a threshold that is deemed trivial (Orwin, 1983). Because a small effect equals  $r = .1$  (Cohen, 1988), we set this threshold to  $r = .05$  and the mean effect size to 0. Publication bias may be present when the Orwin's fail safe  $N$  is lower than the number of independent effect sizes. The rank correlation test, Egger's regression test, and Duval and Tweedie's trim and fill procedure all rely on the assumption that in the absence of publication bias, effect sizes of individual studies are symmetrically distributed around the average effect. However, small studies (i.e., in terms of  $N$ ) with low effect sizes often fail to reach significance and as such are less likely to be published. Thus in the presence of publication bias, the meta-analysis includes a disproportional amount of small sample studies with large effect sizes.

The rank correlation test and Egger's regression test formally test whether small sample studies in a meta-analysis tend to have larger effect sizes than expected, the former using rank orders and the latter using the actual effect sizes (Begg & Mazumdar, 1994; Egger, Smith, Schneider, & Minder, 1997). Significance of these tests indicates presence of publication bias. We used Stata software (version 12) to conduct the Begg and Mazumdar's rank correlation test and the Egger's regression test with the standard errors from the random effects model. Duval and Tweedie's trim and fill procedure imputes the unpublished studies that would have to be added for a more even distribution of studies around the average effect and recalculates the average effect size using these imputed studies (Duval & Tweedie, 2000), which is assumed to be a better estimation of the unbiased average effect size. As suggested by Peters, Sutton, Jones, Abrams, and Rushton (2007) we used a fixed effects model to 'trim' and a random effects model to 'fill' the results.

## Results

### Descriptive Statistics

Our meta-analysis consisted of 29 cross-sectional studies, 12 longitudinal studies, and four experimental studies. Tables 1, 2, and 3 present summaries of the study characteristics of the included studies. The first author can be contacted to provide individual study-level effect sizes. Our sample of studies together included over 155,000 participants, ranging in age from 0 to 18 years. Of the 45 studies, 38 included a measure or manipulation of television viewing, and 17 included a measure or manipulation of video game playing. Most studies ( $k = 40$ ) included a measure of overall amount of television viewing or video game playing. Twelve studies examined violent media content, and three studies examined pacing of media content.

The rating process of the outcome measures revealed that only few studies included a measure that purely reflected one of the three ADHD-related behaviors. Consequently, there were only seven independent effect size estimates available for the outcome variable attention problems, one for hyperactivity, and seven for impulsivity. As a result, we were not able to perform a meta-analysis for the outcome variable hyperactivity. The study measuring hyperactivity reported a positive correlation ( $r = .20$ ) between media use and hyperactivity (Miller et al., 2007). Because there were seven independent effect sizes available for the outcome variables of attention problems and impulsivity, we could calculate an average correlation coefficient but were unable to conduct additional moderator analyses for these outcomes. For the outcome variable ADHD composite, 43 independent effect size estimates were available. Therefore, in addition to calculating an average correlation coefficient for the relationship between media use and ADHD composite measures, we were able to conduct a multiple regression analysis examining the effects of measurement type, media type, media content, study design, age, and sex.

### Overall Meta-Analytic Results

The meta-analyses revealed significant positive relationships between media use and ADHD composite measures,  $r_+ = .12$ , 95% confidence interval (CI) [.09, .14],  $k = 43$ , attention problems,  $r_+ = .32$ , 95% CI [.11, .50],  $k = 7$ , and impulsivity,  $r_+ = .11$ , 95% CI [.00, .22],  $k = 7$ . A heterogeneity analysis revealed a significant difference between ADHD composite and attention problems,  $Q(1) = 44.64$ ,  $p < .001$ , a nonsignificant difference between ADHD composite and impulsivity,  $Q(1) = 0.12$ ,  $p = .726$ , and a marginally significant difference between impulsivity and attention problems,  $Q(1) = 3.25$ ,  $p = .072$ . Because the average correlation between

**Table 1** Characteristics of Cross-sectional Studies Included in This Meta-Analysis

Study	N	% girls	Age (in years)		Outcome <sup>a</sup>	Media type <sup>b</sup>	Media content <sup>c</sup>
			Mean	Range			
Acevedo-Polakovich et al. (2006) <sup>d</sup>	165	37%	7.2	n/a	C	TV	O
Acevedo-Polakovich et al. (2007)	81	32%	n/a	4-6	C	TV	O
	107	32%	n/a	7-9	C	TV	O
C. C. Anderson & Maguire (1978)	102	46%	n/a	8-10	I	TV	O; V
	198	51%	n/a	10-12	I	TV	O; V
Bioulac et al. (2008)	50	12%	11.3	6-16	C	VG	O
Chan & Rabinowitz (2006)	72	57%	15.3	14-16	C; A	TV;VG	O
Connors-Burrow et al. (2011)	92	50%	5.2	4-6	C	TV	O
De Sousa (2011)	315	0%	14.3	n/a	C; A	VG	O
Erdogan et al. (2006)	356	51%	6.0	5-7	C	TV	O
Ferguson (2011)	603	49%	12.4	10-14	C	TV;VG	O; V
Ferguson & Olson (2013)	1,254	53%	12.9	12-14	C	VG	O; V
Greenwood & Lillard (2011)	48	50%	4.5	3-5	C	TV	O
Hastings et al. (2009)	70	50%	7.8	6-10	C	VG	O; V
Kim et al. (2011)	66,707	49%	11.9	6-17	C	TV+VG	O
Knezevic (2009)	33	58%	3.9	3-4	C	TV	O; V
Kronenberger et al. (2005)	54	22%	14.3	13-17	C; A	TV+VG	V
Levine & Waite (2000)	70	47%	10.3	8-11	C	TV	O; V
Lillard & Peterson (2011) <sup>d</sup>	60	47%	4.6	4-4	C	TV	O
Lin & Lepper (1987)	189	42%	n/a	9-12	I	VG	O
Lingineni et al. (2012)	59,880	48%	11.6	5-17	C	TV	O
Maaß, Hahlweg, Heinrichs et al. (2010)	708	41%	4.3	2-6	C	TV;VG	O
Mazurek & Engelhardt (2013)	141	0%	11.7	8-18	C; A	VG	O; V
Milich & Lorch (1994)	40	0%	n/a	7-12	C	TV	O; V
Miller et al. (2007)	170	38%	4.3	2-5	C; H	TV	O
Nikkelen et al. (2014)	1,612	49%	6.0	5-9	C	TV+VG	V
Özmert et al. (2002)	689	50%	8.0	7-9	C	TV	O
Özmert et al. (2011)	581	59%	13.5	12-16	C	TV	O
Schittenhelm et al. (2010)	60	50%	9.8	8-11	C; A	TV	O
Shin (2004)	1,203	50%	9.0	6-13	C	TV	O
van Egmond-Fröhlich et al. (2012)	9,428	48%	11.7	6-17	C	TV	O

Note. <sup>a</sup>C = attention-deficit/hyperactivity disorder (ADHD) composite; A = attention problems; H = hyperactivity; I = impulsivity. <sup>b</sup>TV = television viewing; VG = video game playing; The plus sign (+) indicates a combined measure of television viewing and video game playing. <sup>c</sup>O = overall media use; V = violent media use; <sup>d</sup>Study has a longitudinal design, but the media-ADHD effect size data was considered cross-sectional.

**Table 2** Characteristics of Longitudinal Studies Included in This Meta-Analysis

Study	N	% girls	Age (in years) <sup>a</sup>		Outcome <sup>b</sup>	Media type <sup>c</sup>	Media content <sup>d</sup>
			Mean	Range			
Cheng et al. (2010)	302	49%	1.5	n/a	C	TV	O
Foster & Watkins (2010)	1,159	50%	1.8	1-1	C	TV	O
Gentile et al. (2012)	3,034	28%	11.2	8-17	C	VG	O; V
Johnson et al. (2007)	678	50%	13.7	n/a	C	TV	O
Landhuis et al. (2007)	980	48%	n/a	5	C	TV	O
Maaß, Hahlweg, Naumann et al. (2010)	262	48%	3.8	2-5	A; C	TV; VG	O
Obel et al. (2004)	1,349	n/a	3.5	n/a	C	TV	O
Parkes et al. (2013)	10,500	51%	5.2	5	C	TV; VG	O
Stevens et al. (2009)	2,717	48%	n/a	4	C	TV	O
Swing et al. (2010)	1,323	53%	9.6	6-12	C	TV;VG	O
Tomopoulos et al. (2007)	96	38%	1.8	n/a	C	TV+VG	O
Zimmerman & Christakis (2007)	542	49%	1.6	0-3	C	TV	O; V
	391	44%	5.0	4-6	C	TV	O; V

Note. <sup>a</sup>The mean age and -range represent the age at the first wave of data collection. <sup>b</sup>C = attention-deficit/hyperactivity disorder (ADHD) composite; A = attention problems. <sup>c</sup>TV = television viewing; VG = video game playing; The plus sign (+) indicates a combined measure of television viewing and video game playing. <sup>d</sup>O = overall media use; V = violent media use.

**Table 3** Characteristics of Experimental Studies Included in This Meta-Analysis

Study	N	% girls	Age (in years)		Outcome <sup>a</sup>	Media type <sup>b</sup>	Media content <sup>c</sup>
			Mean	Range			
Anderson et al. (1977)	48	50%	n/a	4	I	TV	F
Cooper et al. (2009)	37	51%	5.2	4-7	A; I	TV	F
Gadberry (1980)	27	56%	6.5	n/a	I	TV	O
Tower et al. (1979)	42	48%	4.1	n/a	C	TV	F

Note. <sup>a</sup>C = attention-deficit/hyperactivity disorder (ADHD) composite; A = attention problems; I = impulsivity. <sup>b</sup>TV = television viewing. <sup>c</sup>O = overall media use; F = fast-paced media use.

composite ADHD and impulsivity did not differ, we combined these studies in subsequent analyses. Step by step removal of outliers in the combined ADHD composite/impulsivity sample resulted in five studies being removed, which only slightly decreased the average correlation coefficient,  $r_s = .10$ , 95% CI [.08, .12], thus we retained these studies in subsequent analyses. There were no outliers in the attention problems data set.

### **Moderator Analyses for ADHD Composite/Impulsivity Combined**

The multiple regression analysis revealed a significant model overall,  $F(6,54) = 5.16$ ,  $p < .001$ ,  $R^2 = .51$ . Regarding the six individual predictors (i.e., age, sex, measurement type, media type, media content, study design), we found that the effect of sex was significant, such that the proportion of girls in each of the studies' samples was negatively related to the studies' effect size,  $b = -0.50$ ,  $SE = 0.11$ ,  $t(54) = -4.50$ ,  $p < .001$ , 95% CI [-0.72, -0.28]. The effect of measurement type was also significant, such that standardized measures had lower effect sizes,  $b = -0.10$ ,  $SE = 0.03$ ,  $t(54) = -3.08$ ,  $p = .003$ , 95% CI [-0.16, -0.03]. Because the effect of measurement type was significant, we performed a heterogeneity test to examine the average correlations for the two individual categories (i.e., standardized and unstandardized). This analysis showed that the average correlation coefficients for both categories were statistically significant - standardized:  $r_s = .11$ , 95% CI [.08, .14],  $k = 41$ ; and unstandardized:  $r_s = .12$ , 95% CI [.06, .18],  $k = 9$ . The other predictors (i.e., age, media type, media content, study design) were not significant in the initial multiple regression model. After the step by step removal of nine outliers, the model remained significant,  $F(6,45) = 17.70$ ,  $p < .001$ ,  $R^2 = .88$ . Again, the effects of measurement type ( $b = -0.14$ ,  $SE = 0.02$ ,  $t(45) = -7.81$ ,  $p < .001$ , 95% CI [-0.18, -0.10]) and sex ( $b = -0.60$ ,  $SE = 0.08$ ,  $t(45) = -7.34$ ,  $p < .001$ , 95% CI [-0.77, -0.44]) were significant, as well as the effect of study design ( $b = -0.03$ ,  $SE = 0.01$ ,  $t(45) = -2.42$ ,  $p = .020$ , 95% CI [-0.06, -0.01]) such that effects sizes of longitudinal studies were lower than effect sizes of cross-sectional studies. A heterogeneity test showed that the average correlation coefficients for both categories were statistically significant - cross-sectional:  $r_s = .13$ , 95% CI [.10, .16],  $k = 42$ ; and longitudinal:  $r_s = .10$ , 95% CI [.06, .14],  $k = 13$ .

### **Publication Bias**

**ADHD composite/impulsivity combined.** Both the rank correlation test ( $z = 0.19$ ,  $p = .847$ ) and the Egger's regression test ( $t = 0.39$ ,  $p = .695$ ) were nonsignificant. Orwin's fail-safe N test resulted in higher number of missing studies ( $k = 66$ ) that would lead to a trivial effect size than the number of included effect sizes. Finally, Duval and Tweedie's trim and fill procedure resulted in six imputed studies on

the left side of the mean. Imputation of these studies lead to an adjusted average correlation coefficient of .09. Generally, these tests indicate that publication bias is not likely to be present.

**Attention Problems.** Orwin's fail-safe  $N$  test resulted in a higher number of missing studies ( $k = 40$ ) that would lead to a trivial effect size than the number of included studies. Both the rank correlation test ( $z = 0.60, p = .548$ ) and the Egger's regression test ( $t = -0.70, p = .515$ ) were non-significant. Finally, Duval and Tweedie's trim and fill procedure resulted in two imputed studies on the right side of the mean. Imputation of these studies led to an adjusted average correlation coefficient of .40. Overall, these results did not indicate a problem of publication bias.

## Discussion

In this meta-analysis we aimed to summarize the findings in the empirical literature on the relationship between media use and ADHD-related behaviors in children and adolescents. We analyzed the relations between media use and four outcomes based on the *DSM-V*: attention problems, hyperactivity, impulsivity, and ADHD as a composite of these three behaviors. Furthermore, we examined differences in these relationships for measurement type (i.e., standardized vs. unstandardized measures of ADHD), media type (i.e., television vs. video games), media content (i.e., overall media use, media violence, and media pacing), study design (correlational, longitudinal, and experimental), age, and sex.

We found that only few of the included studies used a measure that exclusively focused on attention problems, hyperactivity, or impulsivity. Because there was only one study that measured hyperactivity, no meta-analysis could be performed for this outcome. For attention problems, the meta-analysis revealed a moderate correlation with combined measures of media use ( $r_+ = .32$ ). As for impulsivity, the meta-analysis revealed a small, but significant positive correlation ( $r_+ = .11$ ). Although media use was more strongly related to attention problems than to impulsivity, the difference was only marginally significant. Moreover, the results for these two outcomes should be interpreted with caution because the number of studies is low and studies are heterogeneous; that is, individual studies differ greatly in their study designs and samples (i.e., children's age and sex distribution).

### Results for ADHD Composite/Impulsivity Combined

The vast majority of studies included in our meta-analysis used composite measures of ADHD-related behaviors. Our meta-analysis of these studies revealed a positive relationship between all three measures of media use and

composite ADHD-related behaviors ( $r_s = .12$ ). This correlation coefficient did not significantly differ from the correlation coefficient of the studies measuring impulsivity, which were therefore combined in subsequent moderator analyses. When simultaneously examining these moderator variables, we found that the effect sizes for studies that included standardized measures of ADHD were lower than those including unstandardized measures of ADHD, although both type of measures led to significant mean correlations.

We found no difference in the strength of the correlation between television viewing and video game playing, or between overall media use and violent media use. This finding is consistent with the arguments that overall media use (Nigg, 2006; Zimmerman & Christakis, 2007) and violent media use (Christakis, 2009; Kronenberger et al., 2005; Zimmerman & Christakis, 2007) could affect ADHD-related behaviors, although probably through different mechanisms. Too few studies focused on use of fast-paced media to reliably calculate an average meta-analytic correlation.

The effect sizes of cross-sectional studies were higher than those of longitudinal studies, but only after the removal of some outliers. Contrary to our expectations, we found no effect of age on the strength of the media-ADHD correlations. However, we were unable to directly compare effects sizes for different age groups because the great majority of empirical studies reported only one effect size for their entire sample, which often comprised a large age range. Therefore, we could only examine the moderating effect of age in a meta-regression analysis using the mean age of the studies' sample as a predictor of the studies' effect sizes. Although this is a commonly used method in meta-analysis, it is less sensitive. Therefore, our lack of finding age differences in the media-ADHD relationship should not be considered decisive. It is conceivable and in line with other meta-analytic results (e.g., Paik & Comstock, 1994) and theoretical accounts (e.g., Nigg, 2006) that children in early childhood are more vulnerable to violent and fast-paced media than older ones. Future empirical research should be conducted to investigate differences among different age group and fill this important gap in the literature.

Our multiple regression analysis suggests that the relationship between media use and ADHD-related behaviors is stronger for boys than for girls. This finding is consistent with the meta-analysis on violent media use and aggression by Paik and Comstock (1994), but not with two other meta-analyses that found null effects for sex (Anderson & Bushman, 2001; Anderson et al., 2010). Our result, however, should be interpreted with some caution. Again, we were unable to directly compare groups based on participant sex because, remarkably, of all 45 empirical studies, only two studies reported separate effect sizes for boys and

girls (Kim, Mutyala, Agiovlasitis, & Fernhall, 2011; Lin & Lepper, 1987). Because it is theoretically plausible that the relationship between media use and ADHD-related behaviors is different for boys and girls, future research examining sex differences is needed.

### **Gaps in the Literature and Directions for Future Research**

Our meta-analysis was limited by the low number of available effects sizes for the three separate ADHD-related behaviors and for some of our moderators. As a result, several important analyses could not be conducted. Moreover, although it is common practice to use the bivariate  $r$  in meta-analyses, it does not control for other potentially influencing factors. Because the type and number of included covariates differed substantially between studies, we were not able to conduct sub-analyses using partial effect sizes. However, we see our meta-analysis as an important motivator of future research because it points out the gaps in the empirical literature and provides researchers with clear working hypotheses for future research. This is important because the study of the relationship between television and ADHD-related behaviors has been characterized by an ephemeral research interest. Researchers contributed with at most one or two studies, after which they disappeared from the field again. This could be the reason that the empirical studies have typically not been guided by explicit theoretical models. In the remainder of this article, we identify some gaps in the literature and present five crucial directions for future research.

#### **1. Conceptualizing and Disentangling the Three Outcome Measures**

We observed that very few of the included studies in our meta-analysis used outcome measures that purely reflected one of the ADHD-related behaviors (i.e., attention problems, hyperactivity, or impulsivity). Although several authors claimed to have measured one of these behaviors (e.g., attention problems) the scales that they used often also included several items measuring one or two other ADHD-related behaviors. Due to this mix-up of items and scales in the empirical studies, we had to code most outcome measures included in our meta-analysis as an ADHD-composite measure. As a result, the samples of studies measuring individual outcomes were limited and impeded subsequent moderator analyses for the separate outcomes.

This confound in the conceptualization and operationalization of the three ADHD-related behaviors is a serious gap in the literature. It is conceivable that media effects differ for each of these three different ADHD-related behaviors. For example, due to a lack of studies, we were not able to assess the effect of violent media use on the outcomes attention problems, hyperactivity and impulsivity.

However, it is conceivable that violent media use is more strongly related to impulsivity than to attention problems and hyperactivity. One of the main characteristics of aggression is the inability to inhibit inappropriate behaviors, thus to act impulsive (Anderson & Bushman, 2002). Several meta-analyses have shown that violent media content is associated with aggressive behavior (Anderson et al., 2010; Ferguson & Kilburn, 2010; Paik & Comstock, 1994; Sherry, 2001; but see the discussion among Bushman, Rothstein, & Anderson, 2010; Ferguson & Kilburn, 2010; and Huesmann, 2010 about the most recent meta-analyses). It is conceivable, therefore, that media violence may more easily elicit impulsivity rather than attention problems or hyperactivity. However, if the relationship between violent media use and the ADHD composite measures could only be attributed to impulsivity (and either less –or not at all- to attention problems and hyperactivity) the reported media violence ADHD-composite relationships could be spurious. Therefore, there is a vital need for future research disentangling the separate ADHD-related behaviors to single out which specific ADHD-related behaviors are more or less affected by which specific aspects of media use.

## **2. Including Theory-Based Media Use Measures**

Hardly any study in our meta-analysis has focused on the effects of fast-paced media on ADHD-related behaviors. This is surprising because the fast pace of contemporary entertainment media is the very feature that is most often claimed to induce ADHD-related behaviors (e.g., Christakis, 2009; Jensen et al., 1997; Lang et al., 2000). There is a remarkable discrepancy in most studies between their conceptualization and operationalization of fast-paced media use. Whereas most authors theorized that the relationship between media use and ADHD-related behaviors should be attributed to the fast pace of media, they typically investigate the relationship between overall media use and ADHD-related behaviors. This is a serious omission in the literature. Not only are there large differences in the pacing of media entertainment (McCollum & Bryant, 2003), but children also differ greatly in their preferences for fast-paced and arousing media entertainment. Some children like fast-paced and arousing media entertainment, whereas others do not. Lumping together these different children into one crude overall media use measure could easily lead to unreliable and even invalid relationships between media use and ADHD-related behaviors. Therefore, there is a vital need for studies that directly measure or manipulate pacing of media content (e.g., the number of cuts, edits, and scene changes) and that examine the separate effects of pacing on attention problems, hyperactivity, or impulsivity.

### **3. Recognizing Transactional Effects**

Most of the literature on which this meta-analysis is based employed cross-sectional designs or longitudinal designs examining the effect of media use at Time 1 on ADHD-related behaviors at Time 2. Only three of the included longitudinal studies (Gentile, Swing, Lim, & Khoo, 2012; Johnson, Cohen, Kasen & Brook, 2007; Stevens, Barnard-Brak, & To, 2009) have attempted to investigate the reversed causal effects of ADHD-related behaviors on media use. Although it is often assumed that media use causes ADHD-related behaviors, several arguments have been put forward to explain why children who display ADHD-related behaviors might use more and different media compared with typically developing children (Acevedo-Polakovich, 2005; Acevedo-Polakovich, Lorch, & Milich, 2007; Durkin, 2010). First, children with ADHD-related behaviors typically face peer difficulties (Hoza, 2007; Hoza et al., 2005), and as a result, they may often engage in more solitary play activities, such as watching television and playing video games. In addition, ADHD-related behaviors are often associated with parent-child conflict and parenting stress (DuPaul, McGoey, Eckert, & VanBrakle, 2001; Gupta, 2007; Pimentel, Vieira-Santos, Santos, & Vale, 2011), and media use is an activity where parents can enjoy some conflict-free time with their children. Alternatively, children may escape parents by turning to the media, or some parents may use the media to “baby sit” their children.

Finally, because ADHD-related behaviors are associated with low baseline arousal level (Beauchaine, Katkin, Strassberg, & Snarr, 2001; Lazzaro et al., 1999), children with ADHD-related behaviors often show a tendency to engage in arousing activities to compensate for this low baseline arousal (Roberti, 2004). Use of violent or fast-paced media may serve as such an activity. Thus, although media use may induce ADHD-related behaviors, these behaviors, in turn, may also enhance or change media use. Therefore, there is a vital need for comprehensive longitudinal studies, which may not only provide stronger evidence of causality in the relationship between media use and ADHD-related behaviors, but may also identify potential transactional media effects.

### **4. Recognizing Differential Susceptibility to Media Effects**

The media-ADHD literature is characterized by a universal media effects perspective, which presumes that media effects are equal to all individuals. Such an approach is inconsistent with modern media-effects theories (e.g., Slater, 2007; Valkenburg & Peter, 2013b). Most studies in our meta-analysis ignored the moderating role of even the most straightforward individual difference variables, such as age and sex. This is surprising, because there is increasing consensus that children’s susceptibility to media effects depends on a host of person-based (e.g.,

age, sex, temperament) and social (e.g., family environment, peers; Valkenburg & Peter, 2013a) factors. In related research on the effects of violent media on aggression, it has been found, for example, that the effect of violent media on aggression is stronger for aggressive children (Bushman, 1995; Kronenberger et al., 2005) and for children who grow up in aggressive families (Fikkers, Piotrowski, Weeda, Vossen, & Valkenburg, 2013).

It is conceivable that the effect sizes in the present meta-analysis are small because they are “diluted” across too many different children. It is likely that the effects of media use on ADHD-related behaviors hold particularly for a small group of susceptible children. For these children and their families, the effects that we found for the whole population may be stronger. In the future, researchers on the media-ADHD relationship can no longer ignore potential factors that may differentiate the subtle universal effects reported in this meta-analysis. Potential differential susceptibility variables that are worthwhile to include in future studies, besides age and sex (Anderson & Bushman, 2002), are temperament (Valkenburg & Peter, 2013a), adversities in the home environment (e.g., family conflict, marital discord; Biederman, 2005; Nigg, Nikolas, & Burt, 2010), and prenatal adversities (e.g., prenatal alcohol exposure; Nigg et al., 2010).

## **5. More Targeted Theory Testing**

The media-ADHD literature is characterized by an input-output approach. Several hypotheses in the literature have addressed specific mechanisms that might underlie the relations between media use and ADHD-related behaviors, such as arousal, executive functioning, and self-control. However, none of the included studies in our meta-analysis has operationalized the mechanisms to investigate particular explanatory hypotheses. Some of these hypotheses, such as the language development hypothesis and script theory have received criticisms (e.g., Ferguson & Donnellan, 2013; Ferguson & Dyck, 2012). It is therefore even more important to particularly investigate the proposed mechanisms of the relationship between media use and ADHD-related behaviors. Until now, it remains unclear how and why structural (e.g., pace) and content (e.g., violence) features of media may lead to one or more ADHD-related behaviors. Knowledge of the validity of these processes is of great importance, because it may help researchers to develop interventions aimed at reducing media effects on children’s ADHD-related behaviors. Therefore, there is an urgent need for future research that systematically investigates the hypothesized explanatory mechanisms and that singles out which mechanisms are involved for different types of media use and different types of ADHD-related behaviors.

## **Conclusion**

In our meta-analysis, we found a positive relationship between media use and ADHD-related behaviors. More important, the meta-analysis clearly revealed some important gaps in the media-ADHD literature. There is a vital need for empirical research on the effects of fast-paced and violent media on each of the three separate ADHD-related behaviors. Only if future studies are able to address the questions of causality, individual susceptibility, and the underlying mechanisms of the media-ADHD relationship can researchers draw more decisive conclusions about the role of media use in ADHD-related behaviors.

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# Chapter 2

## Children's television viewing and ADHD-related behaviors: Evidence from the Netherlands

### Abstract

This study examined how ADHD-related behaviors are associated with children's overall amount of television viewing, specific content viewing (i.e., violent/scary and educational) and attention and arousal responses when viewing television. Additionally, it explored the moderating role of children's sex in these relationships. To address these aims, parents of 865 Dutch children (3-7 years) completed a survey measuring ADHD-related behaviors and kept four-day television diaries. We found that ADHD-related behaviors were not associated with overall viewing nor with violent/scary content viewing. These relationships, however, were moderated by sex. Further analyses of these moderations revealed a positive trend between ADHD-related behaviors and overall and violent/scary content viewing for boys only. ADHD-related behaviors were not related to educational content viewing. Furthermore, ADHD-related behaviors were related to more arousal when viewing television, regardless of content, and less attention to overall and educational television. We did not find sex differences in arousal and attention responses.

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The past decades have witnessed an increased research interest in the potential relationship between television viewing and attention-deficit/hyperactivity disorder (ADHD). ADHD is a developmental disorder typified by a combination of inattention, hyperactivity, and impulsivity (The Diagnostic and Statistical Manual of Mental Disorders, 5th ed. [DSM-V], American Psychiatric Association, 2013). Although ADHD has traditionally been viewed as a categorical disorder, its behaviors are often considered as existing on a continuum (e.g., Larsson, Anckarsater, Råstam, Chang, & Lichtenstein, 2012), which is a perspective we adopt in the present study. We will refer to this behavioral continuum as *ADHD-related behaviors*.

A recent meta-analysis yielded a small but positive relationship ( $r = .12$ ) between television viewing and ADHD-related behaviors (Nikkelen, Valkenburg, Huizinga, & Bushman, 2014a). However, although informative, this meta-analysis revealed several areas that need further research attention. First, the majority of existing studies have only investigated overall television use without distinguishing between different content types. As a result, we still largely lack knowledge about the relationship between specific content viewing and ADHD-related behaviors. Second, most existing studies have been conducted among children in middle childhood or adolescence (e.g., Ferguson, 2011; Gentile, Swing, Lim, & Khoo, 2012). As such, little is known about the relationship between ADHD-related behaviors and television viewing in early childhood, the age period during which ADHD-related behaviors typically develop (Polanczyk et al., 2010).

Third, we lack knowledge about how ADHD-related behaviors are related to children's specific responses to television. For example, it is plausible to assume that ADHD-related behaviors are associated with less attention and more arousal during television viewing. Knowledge about these specific responses may help generate hypotheses about the underlying mechanisms of the television-ADHD relationship (Valkenburg & Peter, 2013). Fourth and finally, although previous research acknowledges the influence of children's sex on their television viewing preferences (Valkenburg & Janssen, 1999; Valkenburg & Cantor, 2000) and ADHD-related behaviors (Froehlich et al., 2007; Rajendran et al., 2013), the possible moderating effect of sex is largely ignored in empirical studies.

This study addresses the aforementioned issues by conducting a comprehensive survey and television diary study among children in early childhood (i.e., ages 3-7). The television diary enables us to closely examine what content children actually watch and how they respond to that content. Specifically, we aim to examine how ADHD-related behaviors are associated with children's overall amount of television viewing, viewing of different content (i.e., violent/scary and educational television), and their attention and arousal while watching television. In addition,

we will explore the moderating role of children's sex in these relationships.

### **ADHD-Related Behaviors and Television Use**

It has been theorized that ADHD-related behaviors are associated with increased overall television viewing, for three reasons (Acevedo-Polakovich, Lorch, & Milich, 2007). First, children high in ADHD-related behaviors typically experience peer difficulties (Hoza, 2007) and may thus engage in more solitary play activities, such as watching television. Second, because ADHD-related behaviors are associated with parenting stress and parent-child conflict (Johnston & Mash, 2001), parents may be less restrictive in their children's television use to enjoy some stress- and conflict-free time. Third, because children with high ADHD-related behaviors often experience educational difficulties (e.g., getting low grades, Loe & Feldman, 2007), they may be less motivated to do homework or to engage in educational play activities and thus spend more time viewing television. We therefore expect that high ADHD-related behaviors will be related to more television viewing overall.

Aside from overall television viewing, it is often argued that ADHD-related behaviors are associated with a preference for arousing (e.g., violent or scary) content (e.g., Miller et al., 2007), because it induces physiological arousal (Fleming & Rickwood, 2001; Gilissen, Koolstra, van IJzendoorn, Bakermans-Kranenburg, & van der Veer, 2007). ADHD has been linked to low baseline arousal levels (Lazzaro et al., 1999) and to subsequent stimulation-seeking behaviors as a way to increase arousal to an optimal level (optimal stimulation theory, Zentall & Zentall, 1983). Children with high ADHD-related behaviors may therefore be more drawn to arousing television content. In this study, we specifically focus on violent and scary content because frequent exposure to such content has been linked with negative outcomes (e.g., Anderson et al., 2010; Valkenburg, Cantor, & Peeters, 2000). Indeed, the meta-analysis of Nikkelen, Valkenburg et al. (2014a) showed a positive relationship between ADHD-related behaviors and violent media use. However, only two of the included studies measuring violent media use were conducted among young children (Knezevic, 2009; Zimmerman & Christakis, 2007), which were inconclusive about whether or not violent media use and ADHD-related behaviors are related in this age group. Because violent and scary content are both considered arousing, and because these types of content often overlap (Cantor & Nathanson, 1996), in this study we conceptualize arousing content as content that is classified as violent and/or scary (referred to as violent/scary content). We expect that ADHD-related behaviors are positively associated with the amount of violent/scary television content viewing.

Furthermore, it is conceivable that ADHD-related behaviors are associated with less viewing of educational television content. Educational content tends

to be slower paced (McCollum & Bryant, 2003), thereby inducing relatively little arousal. Therefore, educational content may be less appealing to children high in ADHD-related behaviors. This would be of concern because children with high ADHD-related behaviors often experience educational difficulties (Loe & Feldman, 2007) and could take advantage from any extra learning opportunities. Studies examining the association between ADHD-related behaviors and educational content viewing are inconclusive. Whereas one study found a negative relationship between the two (Hastings et al., 2009), other studies found no relationship (Mazurek & Engelhardt, 2013; Milich & Lorch, 1994; Tomopoulos et al., 2007; Zimmerman & Christakis, 2007). Therefore, in the present study we will explore whether ADHD-related behaviors are associated with educational content viewing in young children.

### **ADHD-Related Behaviors, Arousal, and Attention to Television**

**Arousal.** Due to differences in internal arousal functioning, children with high ADHD-related behaviors may show different arousal responses when viewing television than children with low ADHD-related behaviors. There are two opposing hypotheses concerning the arousal functioning of children with high ADHD-related behaviors. First, it is argued that these children typically show high arousing behavior (i.e., act excited, active, jittery) as a way to increase their low baseline arousal to a more pleasant level (e.g., White, 1999). Because exciting television content (i.e., violent/scary content) induces arousal (Fleming & Rickwood, 2001; Gilissen et al., 2007), these children may be less inclined to act excited when viewing such content. According to this hypothesis, high ADHD-related behaviors may be associated with less arousing behavior when viewing arousing (i.e., violent/scary) content. Instead, when viewing general and educational content, children with high ADHD-related behaviors may show more arousing behavior because the content induces little arousal itself. The opposing hypothesis states that ADHD-related behaviors are associated with a 'hypersensitivity' to exciting stimuli (Sikström & Söderlund, 2007). Accordingly, high ADHD-related behaviors may be related to more arousal when viewing violent/scary content compared to low ADHD-related behaviors, but not when viewing television in general or when viewing educational content. To investigate these two hypotheses, we will examine the relationship between ADHD-related behaviors and children's arousal when viewing television in general and when viewing violent/scary or educational content.

**Attention.** Because children with high levels of ADHD-related behaviors have trouble sustaining their attention, it may be expected that they are also less able to focus on television. For example, research has shown that children with ADHD are

more easily distracted when viewing television compared to typically developing children (e.g., Lorch et al., 2000). However, attention to television may differ by content. Violent/scary content is characterized by frequent use of salient formal features, such as character movements, action, and visual effects. Formal features like these continuously draw the viewer's attention to the screen (e.g., Lang, Zhou, Schwartz, Bolls, & Potter, 2000). Children with high ADHD-related behaviors may therefore be just as attentive as children with less ADHD-related behaviors when viewing violent/scary content. Educational content makes specific use of formal features to promote learning, but these are generally less salient (McCollum & Bryant, 2003). Moreover, processing this content may be especially difficult for children with high ADHD-related behaviors, who have trouble sustaining their attention. Therefore, their initial attention response may quickly fade away and they may thus be less attentive to educational content compared to children with less ADHD-related behaviors. In the present study, we will examine these relationships by investigating children's attention levels when viewing television in general and when viewing specific content.

### **Moderating Influence of Children's Sex**

Typically, the effect sizes of the ADHD-media relationship reported in empirical studies are small, which might indicate that this relationship differs between children. One important moderator may be children's sex. For example, Nikkelen, Valkenburg et al.'s (2014a) meta-analysis on the relationship between ADHD-related behaviors and media use showed that the effect sizes of the included studies increased as the proportion of boys in the sample increased, indicating stronger relationships for boys. Differences may emerge especially in arousing content viewing. After all, boys in general are more drawn to television content that contains action and violence than girls (Valkenburg & Janssen, 1999). Boys with high levels of ADHD-related behaviors might therefore be more attracted to violent/scary television content than girls with high levels of ADHD-related behaviors. Differences between boys and girls may also occur in children's television responses, due to temperamental differences. Boys are generally less attentive and have more difficulty inhibiting their behavior compared to girls (Else-Quest, Hyde, Goldsmith, & Van Hulle, 2006), which may strengthen the relationship between ADHD-related behaviors and arousal and attention responses for boys. The final aim of this study is therefore to examine sex differences in all of the aforementioned relationships.

## Method

### Sample

Data were collected by a private Dutch research institute (TNS-NIPO) from September to December 2012. Families were recruited through the research institute's existing online panel (approximately 60,000 representative Dutch households). This study is part of a larger design in which the inclusion of sibling data was necessary. Hereto, the research institute recruited 521 families with at least two children between three and seven years old. Given that ten out of eleven children in the Netherlands grow up in multi-child families (CBS, 2003), this sample provided a sufficient representation of Dutch children. Two children from each family participated, resulting in a total of 1,042 children, of whom 934 had complete survey data. Of these 934 children, 69 were excluded due to incomplete television diary data, leading to our final sample of 865 children (52% female, 99% sibling pairs) with a mean age of 5.40 ( $SD_{\text{age}} = 1.40$ ) and an even age distribution (20% 3 yrs.; 21% 4 yrs.; 20% 5 yrs.; 21% 6 yrs.; 18% 7 yrs.). Our sample was well represented in terms of parent's educational level (<1% primary; 15% secondary; 33% vocational; 52% higher education).

### Procedure

We collected data using television diaries and a survey, completed by one of the parents. Television diaries were completed online to measure children's television viewing and their arousal and attention responses. Parents have previously proven to be a reliable source when measuring children's television viewing using television diaries (D. R. Anderson, Field, Collins, Lorch, & Nathan, 1985). Surveys were administered on a laptop during a home visit by an interviewer to measure ADHD-related behaviors and demographics. Because the planning of the television diaries and home visits occurred separately, the order in which the diaries and the survey were filled out varied between respondents (i.e., survey first [2%], diary first [52%], or the survey in between diary days [46%]).

### Television Diaries

For both children, parents filled out the television diary on four days: a Friday, Saturday, Sunday, and random weekday. These four days were spread across a one-month period without overlapping days between siblings. Parents were notified via email and text message a day prior to each diary day. The diary was filled out in the evening (after 8 pm) to document the children's television use during the previous 24 hours. As a memory aid, parents received a shortened printed diary to keep notes of their children's television use. In total, parents of 785 respondents

had completed all four diaries. As a trade-off between sample size and the reliability of the television measures, we included respondents with at least three completed diaries, resulting in our total sample of 865 respondents. There were no differences between included and excluded respondents concerning sex,  $\chi^2(1, N = 934) = 0.08, p = .804$ , age,  $t(932) = 0.14, p = .888$ , ADHD-related behaviors,  $t(75.20) = 0.41, p = .683$ , or birth order,  $t(932) = 0.40, p = .691$ . Included participants had slightly higher SES,  $t(932) = -4.49, p < .001$ .

Each diary day was split into five time slots: (1) previous evening, from 8 pm to bedtime, (2) 6 am to noon, (3) noon to 3 pm, (4) 3 to 6 pm, and (5) 6 to 8 pm. For each time slot, parents reported whether their child had watched television programs or movies, including real-time viewing, on-demand viewing, and viewing through DVDs or on YouTube. If so, we asked parents to write down the program or movie title. If parents forgot the title, they could indicate on which broadcasting station it aired (this was the case for 8% of all titles), so we could look it up. Subsequently, we asked during which half-hour time blocks the title was viewed. Finally, we asked about the child's responses to each title (discussed below). Parents could fill out up to five television programs and five movies per time slot.

**Overall television viewing.** To calculate overall television viewing, we used a three-step approach. First, for each day separately, we summed all half-hour time intervals in which the child had viewed television programs or movies. Second, we averaged these daily measures - separately for weekdays and weekend days. Third, we multiplied average weekday viewing by five and average weekend day viewing by two and summed these measures to calculate overall viewing in hours per week ( $M = 8.09, SD = 5.36$ ). This three-step approach was necessary because children typically watch more television during weekend days, and the number of completed diaries varied between children. Simply averaging the daily measures would therefore lead to an imprecise estimate.

**Types of television content.** Two trained coders coded whether the programs and movies listed in the television diaries contained violent/scary or educational content (see below for the coding process). Entries with unclear, ambiguous, or multiple titles were handled as missing data. On average, 82% of respondents' television viewing consisted of clear titles that could be coded. All diaries together resulted in a total of 1,112 unique titles to be coded, of which twenty-five percent were coded as violent/scary and seven percent were coded as educational. Twenty-five percent of the unique titles were double-coded to measure inter-rater reliability.

*Coding of violent/scary content.* Presence of violent/scary content was coded using the Dutch television and movie rating system, the 'Kijkwijzer' (Valkenburg, Beentjes, Nikken, & Tan, 2008). The Kijkwijzer is based on a 60-item questionnaire

that broadcasting companies and movie distributors complete to rate their productions. The specific questionnaire responses result in an age and content rating (e.g., whether or not the production contains violent, scary, sexually-explicit content, etc.). All programs and movies that have currently been rated by the industry are included in an online, publicly accessible database (kijkwijzer.nl). Coders coded the titles in the television diaries in two steps. First, coders searched for the title on the website of the Kijkwijzer. If ratings for the title were available from the website, coders coded the title for the presence of violent and/or scary content (0 = *absent*, 1 = *present*). Second, titles with no current rating in the online database (7% of all titles) were watched and rated by our coders using the 60-item Kijkwijzer questionnaire. To code television programs, coders watched two randomly chosen episodes of the most recently aired season. Movies were watched in their entirety. Inter-rater reliability was high, with a percentage of agreement of 96% and a kappa coefficient of .90 (Viera & Garrett, 2005).

*Coding of educational content.* Because the Kijkwijzer only informs about potential harmful content, we designed a coding scheme for educational content. Coders were instructed to look up each title online and primarily look for its official website. If no official website existed, coders searched other websites containing information about television and movie titles (i.e., mediasmarties.nl; commonsensemedia.org; imdb.com; and esrb.org). Using the information on these websites, coders coded each title for the presence of educational content (0 = *absent*, 1 = *present*). Educational content was defined as “content in which the primary goal is to enhance children’s perceptual and cognitive skills and to prepare them for school: teaches counting, basic math, and reading.” Titles were only coded as containing educational content if it consisted a major part of the title’s regular formula. Inter-rater reliability was acceptable, with a high percentage of agreement of 95% and a moderate mean kappa of .57 (Viera & Garrett, 2005).

*Calculation of content viewing.* Viewing of violent/scary and educational content was calculated using the same three-step approach that was used for overall television viewing. This calculation resulted in average weekly viewing (in hours per week) of violent/scary ( $M = 1.17$ ,  $SD = 1.94$ ) and educational content ( $M = 1.01$ ,  $SD = 1.81$ ).

**Arousal and attention.** For each title, arousal was measured by asking: “How excited or active did your child feel when watching this television program [movie]?” Parents indicated their children’s arousal using the 5-point Self-Assessment Manikin which we adapted to parent-report. The self-report measure has been validated in previous research (SAM, Bradley & Lang, 1994). The SAM for arousal consists of a series of graphical figures that illustrate increasing arousal.

The graphical pictures were combined with verbal anchors, ranging from 1 (*not at all excited or active*) to 5 (*very excited or active*). Attention was measured by asking for each title: "How much did your child pay attention to what happened in the television program [movie]?" Responses ranged from 1 (*very little*) to 5 (*a lot*). Per participant, we first averaged the scores for arousal and the scores for attention for all titles, over all diary days, to calculate overall arousal ( $M = 1.91$ ,  $SD = 0.75$ ) and overall attention ( $M = 3.93$ ,  $SD = 0.49$ ). In addition, we calculated separate arousal scores for violent/scary ( $M = 2.06$ ,  $SD = 1.04$ ) and educational content ( $M = 1.93$ ,  $SD = 0.94$ ),  $t(154) = 2.58$ ,  $p = .011$ . Finally, we calculated attention scores for violent/scary ( $M = 3.89$ ,  $SD = 0.80$ ) and educational content ( $M = 3.95$ ,  $SD = 0.71$ ),  $t(154) = 0.48$ ,  $p = .631$ .

### Survey Measures

**ADHD-related behaviors.** We measured ADHD-related behaviors using the Dutch ADHD questionnaire (Scholte & Van der Ploeg, 2010). This questionnaire consists of 18 items, closely matching the ADHD criteria in the DSM-V (American Psychiatric Association, 2013). The ADHD questionnaire has shown good validity with the 'attention problems' subscale in the Child Behavior Checklist (CBCL, Achenbach, 2009; Scholte & Van der Ploeg, 2010). Items were rated on a five-point scale with 0 = *never*, 1 = *sometimes*, 2 = *regularly*, 3 = *often*, 4 = *very often*. Summing all 18 items created the total ADHD score ( $M = 17.49$ ,  $SD = 12.03$ ,  $\alpha = .93$ ).

**Control variables.** The analyses controlled for children's age (Valkenburg & Cantor, 2001) socioeconomic status (SES, Gorely, Marshall, & Biddle, 2004), and birth order (Nikkelen, Vossen et al., 2014b). Age was measured in years and months. SES was calculated as a composite of parents' educational level and household income. 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 averaging the standardized scores of educational level and household income. Birth order referred to the child's rank in age among his or her siblings, with 1 = *first born*, 2 = *second born*, etc.

### Statistical Analyses

For overall television viewing and arousal and attention responses, we conducted linear regression analyses using robust clustering to correct for the clustered nature of our data (i.e., sibling data). For violent/scary and educational content viewing, we conducted Zero-Inflated Negative Binomial (ZINB) regression

analysis using robust clustering. ZINB regression accounts for over dispersed outcome variables with excess zeros, which violate the normality assumption of OLS regression (Lambert, 1992). To illustrate, in our sample, 50.6% of children watched zero hours of violent/scary television. The Vuong test for excess zero's and the log-likelihood to test for over dispersion were significant for all ZINB analyses ( $p < .01$ ). Because ZINB regression is performed on integer dependent variables, we first rounded respondent's scores for violent/scary and educational viewing to the nearest hour. Subsequently, high single scores that were relatively distant from the other scores, as indicated by a histogram of the data distribution, were recoded to the nearest value because singular high values greatly affect the model's parameter estimates (Osborne & Overbay, 2004). These averaged, rounded scores of violent/scary content viewing and educational content viewing were used as the dependent variables in the ZINB regression analyses. ZINB regression breaks down the analysis into two models: an 'inflate' model examining the effect of predictors on the probability of scoring  $> 0$  on the outcome and a 'count' model examining the effect of the predictors on the magnitude of the score. For the sake of clarity, and because we were only interested in the effect of predictors on the *magnitude* of respondents' scores on our outcome variables, we only present results for the count model. Because regression coefficients are interpreted differently in ZINB regression, we converted them to incidence rate ratios (IRR), which are interpreted as the percentage of change in the outcome associated with a 1-unit change in each predictor. For each outcome variable, we first examined the main effects of the control variables, sex and ADHD-related behaviors (Step 1). Subsequently, we added the interaction between sex and ADHD-related behaviors (Step 2).

We examined multivariate outliers using Mahalanobis distance. Cases were considered multivariate outliers when their distance score was particularly remote from other distance scores. Two individuals were identified as outliers for the combination of variables entered in Step 1, and one for the combination of variables entered in Step 2. Outliers were excluded from the analyses<sup>1</sup>.

## Results

### Descriptive Statistics and Zero-Order Correlations

Table 1 presents the zero-order correlations between the main variables in

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<sup>1</sup>We have checked whether results were different when outliers were excluded or included, and found that this was only the case for exposure to educational television content. This relationship was significant with inclusion of outliers, but non-significant upon exclusion of the outliers. Because the initial result (for the full sample, including outliers) was not robust and influenced by only a few cases, we only describe the findings excluding the outliers.

this study and the descriptive statistics for boys and girls separately. ADHD-related behaviors were not related to overall television viewing or specific content viewing. Concerning arousal responses, ADHD-related behaviors were positively related to arousal to overall, as well as violent/scary and educational television. In contrast, ADHD-related behaviors were negatively correlated with attention to overall and educational television. Compared to girls, boys displayed more ADHD-related behaviors and watched more violent/scary television.

**Table 1** Bivariate correlations between main study variables and descriptive statistics separately for boys and girls

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. ADHD-related behaviors										
2. Overall TV	.01									
3. Violent/Scary TV <sup>a</sup>	.04	.35***								
4. Educational TV <sup>a</sup>	.03	.39***	-.05							
5. Arousal: Overall	.23***	.07*	.05	.14***						
6. Arousal: Violent/scary	.23***	.09	.05	.14**	.77***					
7. Arousal: Educational	.19***	.03	.03	.17**	.78***	.46***				
8. Attention: Overall	-.12***	-.08*	.01	-.00	.08*	.08	.04			
9. Attention: Violent/scary	-.04	-.04	.11*	-.13*	.06	.11*	-.03	.65***		
10. Attention: Educational	-.13*	-.06	-.09	.06	.03	.07	.01	.65***	.11	
Age	-.01	-.09*	.08*	-.27***	.00	-.01	-.06	.04	.22***	-.07
SES	-.10**	-.03	-.04	-.03	-.12***	-.08	-.11*	.00	-.07	-.06
Birth order	-.04	-.03	.02	-.03	-.01	-.06	.01	-.09**	-.19***	.09
Mean (SD)										
Boys	18.91 <sup>b</sup> (11.84)	8.08 (5.60)	1.38 <sup>b</sup> (2.07)	0.94 (1.67)	1.96 (0.73)	2.15 (1.01)	1.91 (0.94)	3.93 (0.50)	3.92 (0.80)	3.92 (0.69)
Girls	16.06 (11.62)	8.10 (5.14)	1.11 (1.82)	1.10 (1.81)	1.87 (0.77)	1.96 (1.07)	1.94 (0.94)	3.93 (0.47)	3.85 (0.80)	3.98 (0.72)

Note. <sup>a</sup>Rounded and recoded variables; <sup>b</sup>Sex difference is significant at  $p < .05$ .

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

### Relationship between ADHD-related Behaviors and Television Viewing

The OLS regression analysis for overall viewing and the ZINB regression analysis for violent/scary content viewing showed no main effect of ADHD-related behaviors on both, but a significant interaction with sex, see Table 2. For overall television viewing, a simple slopes analysis using STATA's 'margins' function showed a positive, marginally significant relationship between ADHD-related behaviors and overall television viewing for boys ( $b = 0.04$ ,  $SE = .02$ ,  $z = 1.75$ ,  $p = .081$ , 95%CI [-0.00, 0.08]) and a non-significant relationship for girls ( $b =$

-0.03,  $SE = .02$ ,  $z = -1.37$ ,  $p = .172$ , 95%CI [-0.07, 0.01]). A simple slopes analysis for violent/scary television viewing revealed a comparable image, with a marginally significant positive relationship for boys ( $IRR = 1.02$ ,  $SE = .01$ ,  $z = 1.90$ ,  $p = .058$ , 95%CI [-0.00, 0.03]) and no relationship for girls ( $IRR = 0.99$ ,  $SE = .01$ ,  $z = -0.20$ ,  $p = .839$ , 95%CI [-0.02, 0.01]). The interactions are visualized in Figure 1 (overall television) and Figure 2 (violent/scary television viewing). The ZINB regression analysis for educational television viewing showed no main effect of ADHD-related behaviors and no interaction effect with sex (see Table 2).

**Table 2** Multiple regression results for the relationship between sex, ADHD-related behaviors and television viewing

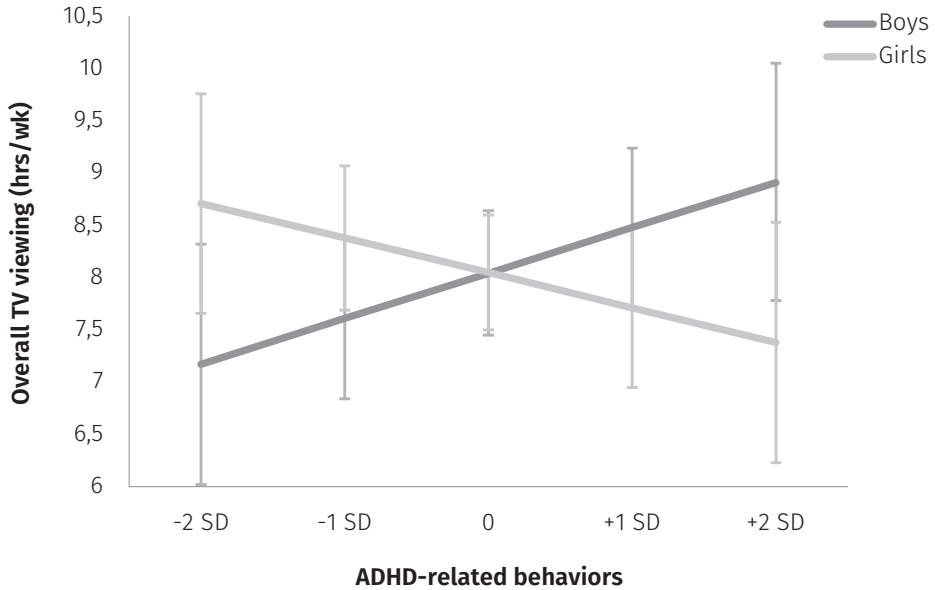
	Overall TV <sup>a</sup> ( <i>N</i> = 865)		Violent/Scary TV <sup>b</sup> ( <i>N</i> = 865)		Educational TV <sup>b</sup> ( <i>N</i> = 865)	
	<i>b</i> ( <i>SE</i> )	<i>t</i>	<i>IRR</i> ( <i>SE</i> )	<i>z</i>	<i>IRR</i> ( <i>SE</i> )	<i>z</i>
Age	-0.46 (.16)	-2.90**	1.13 (.07)	1.97*	0.71 (.06)	-3.93***
SES	(Excluded) <sup>f</sup>		0.82 (.08)	-2.07*	0.82 (.08)	-2.11*
Birth order	-0.49 (.25)	-1.97*	1.32 (.12)	3.03**	0.73 (.08)	-2.81**
Sex <sup>c</sup>	0.00 (.35)	-0.01	0.87 (.11)	-1.17	1.13 (.16)	0.90
ADHD	0.04 (.02)	1.75	1.02 (.01)	2.27*	1.03 (.16)	1.42
Sex*ADHD	-0.07 (.03)	-2.22*	0.97 (.01)	-2.70**	-	-
<i>R</i> <sup>2</sup> / Pseudo <i>R</i> <sup>2</sup> <sup>d</sup>	.02		.04		.15	
<i>F</i> / Wald $\chi^2$ <sup>e</sup>	2.51*		34.97***		25.59***	

*Note.* <sup>a</sup>Results from OLS regression; <sup>b</sup>Results from Zero-Inflated Negative Binomial Regression, *IRR* = incidence rate ratio; <sup>c</sup>0 = *boys*, 1 = *girls*; <sup>d</sup>For overall TV, *R*<sup>2</sup> is reported, for violent/scary and educational TV, the Cox and Snell's *R*<sup>2</sup> is reported. <sup>e</sup>For overall TV, *F* is reported, for violent/scary and educational TV, the Wald  $\chi^2$  is reported. <sup>f</sup>Because the overall model fit was not significant for the initial model, non-significant control variables were excluded.

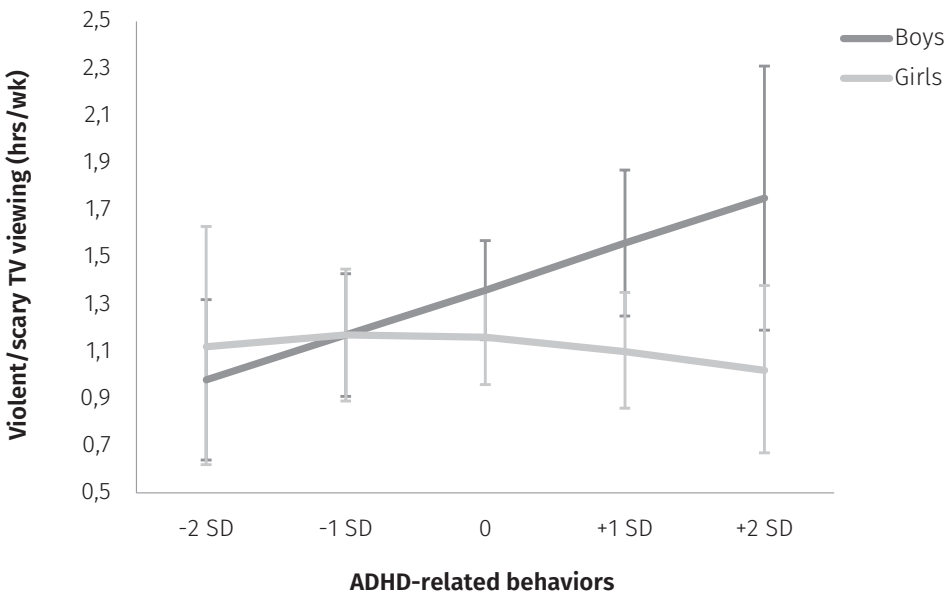
\* $p < .05$ . \*\* $p < .01$ . \*\*\* $p < .001$ .

### Relationship between ADHD-related Behaviors and Arousal Responses

The OLS regression analyses for arousal to overall, violent/scary, and educational television showed significant positive relationships between ADHD-related behaviors and arousal responses, see Table 3. We found no interaction with sex for either of the three variables. The relationships between ADHD-related behaviors and arousal to overall, violent/scary, and educational television are visualized in Figure 3.



**Figure 1** Relationship (+95% CI) between ADHD-related behaviors and overall television viewing, separately for boys and girls.



**Figure 2** Relationship (+95% CI) between ADHD-related behaviors and violent/scary television viewing, separately for boys and girls.

### **Relationship between ADHD-related Behaviors and Attention Responses**

OLS regression analyses showed negative relationships between ADHD-related behaviors and attention to television overall and to educational content, see Table 3. There was no main effect of ADHD-related behaviors and attention to violent/scary television. Neither of the relationships were moderated by children's sex. The relationships between ADHD-related behaviors and attention to overall, violent/scary, and educational television are visualized in Figure 4.

## **Discussion**

This study aimed to examine how ADHD-related behaviors are associated with specific television viewing patterns in young children and the moderating role of children's sex in these relationships. Our findings indeed indicate several content- and sex-specific differences in the television use and responses between children who display high ADHD-related behaviors and those with less ADHD-related behaviors.

### **Findings Concerning Television Exposure**

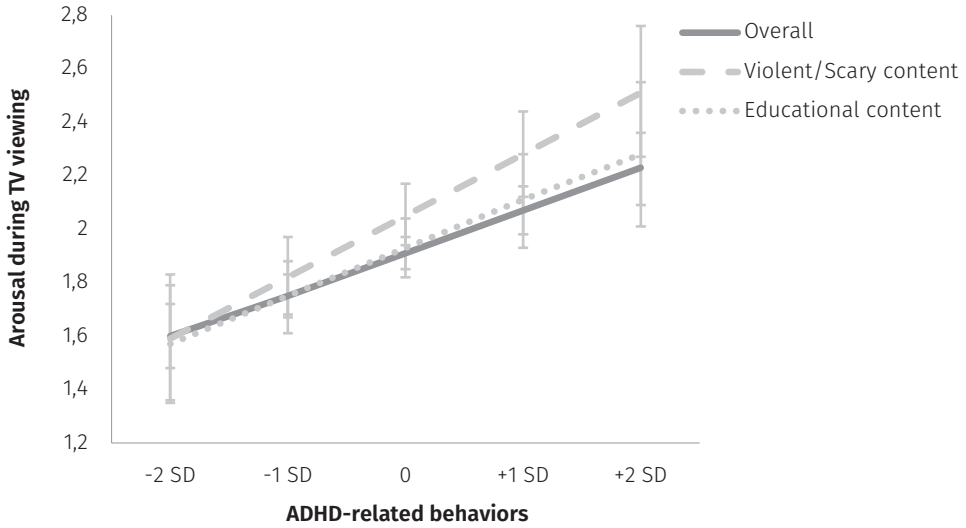
In contrast to our expectations based on previous studies (e.g., Acevedo-Polakovich et al., 2007), we did not find a significant relationship between ADHD-related behaviors and overall television viewing. However, in line with a recent meta-analysis (Nikkelen, Valkenburg et al., 2014) we did find an interaction with child's sex, indicating significant differences between boys and girls in this relationship. Further analysis showed a positive trend between ADHD-related behaviors and overall television viewing for boys only. The same was true for the relationship between ADHD-related behaviors and amount of violent/scary content viewing, which was also moderated by sex, with a positive trend for boys only. This finding is consistent with a meta-analysis on the violent television-aggression relationship (Paik & Comstock, 1994). Thus, not only do boys display more ADHD-related behaviors and are they more attracted to violent and action-packed media content, they also show stronger relationships between these two factors. Finally, we found no relationship between ADHD-related behaviors and the amount of viewing of educational television, and no moderation by sex. Despite its slower pace, educational content may appeal as much to children displaying more and those displaying less ADHD-related behaviors.

**Table 3** OLS regression results for the relationship between sex, ADHD-related behaviors and arousal and attention responses

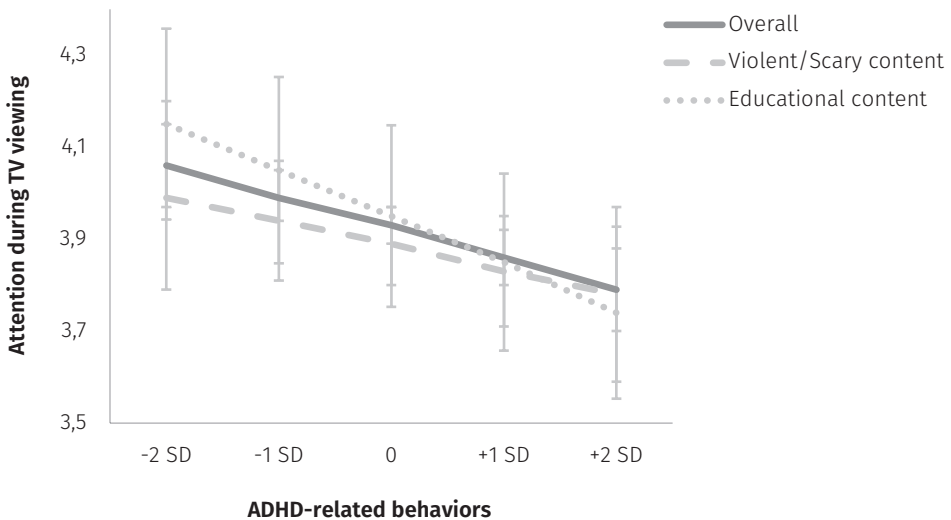
	Overall TV (N = 835)			Arousal responses Violent/Scary TV (N = 386)			Educational TV (N = 361)			Overall TV (N = 835)			Attention responses Violent/Scary TV (N = 386)			Educational TV (N = 361)		
	b (SE)	t		b (SE)	t		b (SE)	t		b (SE)	t		b (SE)	t		b (SE)	t	
Age	-0.00 (.02)	-0.01		-0.03 (.04)	-0.69		-0.04 (.05)	-0.83		-0.00 (.01)	-0.10		0.09 (.03)	2.78**		(Excluded) <sup>b</sup>		
SES	-0.11 (.05)	-2.42*		-0.08 (.08)	-0.92		-0.14 (.09)	-1.63		-0.01 (.03)	-0.43		-0.09 (.07)	-1.30		(Excluded) <sup>b</sup>		
Birth order	-0.01 (.04)	-0.12		-0.09 (.07)	-1.25		-0.01 (.09)	-0.17		-0.06 (.03)	-2.14*		-0.13 (.06)	-2.13*		(Excluded) <sup>b</sup>		
Sex <sup>a</sup>	-0.06 (.06)	-1.02		-0.15 (.11)	-1.39		0.07 (.10)	0.71		-0.03 (.03)	-0.84		-0.09 (.08)	-1.11		0.03 (.08)	0.39	
ADHD	0.01 (.00)	5.60***		0.02 (.00)	4.25***		0.02 (.00)	3.14**		-0.01 (.00)	-3.31**		-0.00 (.00)	-1.16		-0.01 (.00)	-2.60*	
Sex*ADHD	-	-		-	-		-	-		-	-		-	-		-	-	
R <sup>2</sup>	.06			.06			.05			.03			.07			.02		
F	8.27***			5.00***			2.61*			3.13**			5.82***			3.53*		

Note. <sup>a</sup>0 = boys, 1 = girls. <sup>b</sup>Because the overall model fit was not significant for the initial model, non-significant control variables were excluded.

\*p < .05. \*\*p < .01. \*\*\*p < .001.



**Figure 3** Relationship (+95% CI) between ADHD-related behaviors and arousal when viewing television, separately for overall, violent/scary and educational television viewing.



**Figure 4** Relationship (+95% CI) between ADHD-related behaviors and attention when viewing television, separately for overall, violent/scary and educational television viewing.

### **Findings Concerning Arousal and Attention Responses**

Children who displayed more ADHD-related behaviors showed more arousal (e.g., excited, active, and jittery behavior) when viewing television in general and when viewing violent/scary or educational television. These results held for both boys and girls. One could argue that this heightened arousal merely reflects general hyperactivity of these children. However, in general, children's arousal to educational content was lower than their arousal to violent/scary content, which indicates that our arousal measure actually measured children's arousal response to the specific content viewed, and not just children's overall hyperactivity. Our findings are in line with the hypersensitivity hypothesis, which states that children high in ADHD-related behaviors show more arousal when exposed to exciting stimuli. We found this to be true not only for violent/scary content, but also for overall and educational television. Given that arousal is frequently hypothesized to play a role in the relationship between ADHD-related behaviors and media use, our study may inspire future studies to specifically test the underlying role of arousal in the media-ADHD relationship.

ADHD-related behaviors were negatively associated with attention to television viewing in general and educational content, but not to violent/scary content. There were no sex differences in these relationships. These results are in line with our expectation that when television content contains less salient formal features, as is generally true for educational content, children who display more ADHD-related behaviors pay less attention to this content. This finding suggests that these children may not benefit from the positive effects that educational content potentially has on their cognitive skills (e.g., Wright et al., 2001). This implication is worrisome given that children with high levels of ADHD-related behaviors often face educational difficulties (Loe & Feldman, 2007) and may thus have a greater need for activities that potentially enhance their cognitive skills compared to children with less ADHD-related behaviors. In recent years, educational media for children has become a multimillion industry. Much research and money is dedicated to making quality media products that specifically draw and hold the attention of children. Our results suggest that more research is needed to examine how children high in ADHD-related behaviors view educational programs and how educational programs can keep the attention of these children.

### **Limitations and Directions for Future Research**

The findings of our study should be considered in the light of three limitations. First, our sample size was too small for some of our analyses. For example, arousal and attention responses to specific media content were only measured if the child actually used that specific media content. A considerable part of our sample

did not watch any violent/scary or educational content. As such, the sample sizes for the analyses of arousal and attention to violent/scary and educational were smaller ( $N = 386$  for violent/scary and  $N = 361$  for educational content) than the sample sizes for the analyses regarding exposure ( $N = 865$ ). This may partially explain why we found sex differences with the exposure measures and not for the response measures. Future studies using larger sample sizes might have more statistical power to reveal possible sex differences.

A second limitation concerns our use of parent report measures of attention and arousal. Parent reports may be biased because of the personal involvement of the parent with the child. Moreover, parents may keep sex-stereotypical behavior in mind when reporting on their children's arousal and attention responses (e.g., boys are generally more active, thus heightened arousal may not have been reported as such). This may explain why we found no sex differences for these measures. However, by using parent reports, we were able to specifically match television exposure with children's responses. Still, our study should be seen as a first step in discovering the role of attention and arousal in the relationship between ADHD-related behaviors and television use. Future observational and experimental studies are needed to validate these measures and confirm our findings.

Finally, due to the cross-sectional nature of our data, we cannot draw conclusions about the direction of our results. Although television use may be a function of ADHD-related behaviors, there are also hypotheses stating that television viewing, particularly exciting content, increases ADHD-related behaviors (e.g., Christakis, Zimmerman, DiGiuseppe, & McCarty, 2004; Levine & Waite, 2000). In addition, the effect may work in both directions, indicating a reinforcing spiral effect (Slater, 2007). To our knowledge, only one study considered both relationships in a sample of children in early childhood (Stevens, Barnard-Brak, & To, 2009). Although this study found no relationship between television viewing and ADHD-related behaviors over time, the authors did not examine the moderating influence of sex, and focused only on overall amount of television viewing. Research further exploring the bi-directional relationships between ADHD-related behaviors and television viewing is therefore urgently needed.

## **Conclusion**

The findings of this study suggest that ADHD-related behaviors are associated with differences in both television viewing and responses to television content. These findings form an important first step towards the conceptualization and investigation of more nuanced models on the relationship between media use and ADHD-related behaviors. Future research should not only distinguish

between different types of content that children are exposed to, but also more systematically conceptualize and model mediating (e.g., attention, arousal) and moderating (e.g., sex, age, temperament) factors. Only by investigating such indirect and conditional effects models are we able to arrive at a true understanding of the relationship between media use and ADHD-related behaviors.

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# Chapter 3

## **Media violence and children's ADHD-related behaviors: A genetic susceptibility perspective**

### **Abstract**

This study examined the relationship between media violence exposure and attention-deficit/hyperactivity disorder (ADHD) -related behaviors. Using survey (parent-reported) and genetic data of 1,612 Dutch children (aged 5 to 9 years), we examined genetic disposition as a possible cause of individual differences in children's use of and susceptibility to media violence. The gene variant of interest was the 5-HTTLPR polymorphism, which has been associated with ADHD-related behaviors in previous research. Results showed that the "long" variant of the gene polymorphism was related to greater violent media use, which in turn was related to more ADHD-related behaviors. The 5-HTTLPR genotype did not moderate the effect of media violence on ADHD-related behaviors. This study provides insight into the role of genetic factors in media effects.

### **This chapter is published as:**

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Attention-deficit/hyperactivity disorder (ADHD) is one of the most common childhood behavioral disorders, with prevalence estimates ranging from 5 to 6% in Western countries (Polanczyk, de Lima, Horta, Biederman, & Rohde, 2007). Traditionally, ADHD has been viewed as a discrete disorder, characterized by extreme levels of inattentiveness, hyperactivity, and impulsivity (American Psychiatric Association [DSM-V], 2013). In recent years, a growing number of authors conceive ADHD as the extreme end on a continuum of behaviors (Larsson, Anckarsater, Råstam, Chang, & Lichtenstein, 2012; Lubke, Hudziak, Derks, van Bijsterveldt, & Boomsma, 2009), a perspective that is adopted in this study. We refer to this continuum as ADHD-related behaviors. Children displaying excessive ADHD-related behaviors typically face several other problems, including academic underachievement (Daley & Birchwood, 2010), impaired peer relationships (Diamantopoulou, Henricsson, & Rydell, 2005), aggressiveness (Waschbusch, 2002), and increased risk for later substance abuse (Molina & Pelham, 2003).

There have been recurrent claims in the literature that specific features of entertainment media may cause children's ADHD-related behaviors (e.g., Christakis, 2009; Nigg, 2006). The average time that children spend with entertainment media has increased dramatically in recent decades (Rideout, Foehr, & Roberts, 2010). Moreover, entertainment media have become more fast-paced, arousing, and violent (Carnagey & Anderson, 2004; Gentile & Anderson, 2003), and have been targeting children at an ever younger age. Several scholars have attributed the potential effects of entertainment media on ADHD-related behaviors to their violent nature (Kronenberger et al., 2005a; Levine & Waite, 2000; Zimmerman & Christakis, 2007). These scholars argue that violent media entertainment may (a) negatively affect children's basic arousal level or (b) disturb their development of self-control, which may both lead to attention problems, hyperactivity, and impulsivity (Huizinga, Nikkelen, & Valkenburg, 2013).

Several earlier studies have investigated the relationship between exposure to violent media and ADHD-related behaviors. Most of these studies have yielded positive albeit modest relationships between violent media use and measures of ADHD-related behaviors (Anderson & Maguire, 1978; Hastings et al., 2009; Kronenberger et al., 2005a; Levine & Waite, 2000; Zimmerman & Christakis, 2007). However, although research on the media-ADHD relationship has been burgeoning, little attention has been paid to individual differences between children that may shape this relationship. Children greatly differ in their preference for and susceptibility to media violence (Huesmann & Taylor, 2006; Valkenburg & Cantor, 2000). For example, children who exhibit a high level of trait aggression have stronger preferences for violent media, and are more readily affected by such media (Bushman, 1995; Kronenberger et al., 2005b). To fill this gap in the literature,

this study investigated how individual differences predict exposure to media violence and moderate its effect on ADHD-related behaviors.

An important variable that may explain individual differences in the uses and effects of media violence on ADHD-related behaviors is children's genetic disposition. This assumption is based on two earlier research findings. First, the heritability of ADHD-related behaviors is among the highest compared to other behaviors (Bergen, Gardner, & Kendler, 2007), with estimates around 76% (e.g., Faraone et al., 2005; Nikolas & Burt, 2010; Thapar, Harrington, Ross, & McGuffin, 2000). Second, overall media use has also been shown to be partly heritable, with estimates ranging from 7 to 35%, depending on the measure of media use and the employed methods (Kirzinger, Weber, & Johnson, 2012; Plomin, Corley, DeFries, & Fulker, 1990). It is therefore conceivable that violent media use is also partly influenced by genetic factors. Given that both ADHD-related behaviors and media use are partly heritable, it seems reasonable to include genetic factors in media-uses-and-effects models considering ADHD-related behaviors.

### **Disposition-Content Congruency Hypothesis**

This study is guided by Valkenburg and Peter's (2013) disposition-content congruency hypothesis, which explains why dispositions simultaneously predict children's media use and enhance media effects. Valkenburg and Peter argue that children have a tendency to seek out media that do not diverge too much from their pre existing cognitions, emotions, attitudes, and behavior (Oliver, Kim, & Sanders, 2006). Dispositionally congruent media content is expected to enhance media effects for two reasons. First, it stimulates children's information processing. In comparison to dispositionally incongruent content, processing of congruent media content requires less cognitive effort because it can be related to more existing mental schemata of the media user (Alba & Hutchinson, 1987; Lang, 2009). Because children can allocate more resources while processing dispositionally congruent media content, this content can enhance media effects. Second, dispositionally congruent content is more likely to strengthen children's experience of familiarity with the content or at least their illusion of familiarity (Whittlesea, 1993). This familiarity heightens pleasure while watching, which has in turn been shown to enhance media effects (Goldberg & Gorn, 1987; Mathur & Chattopadhyay, 1991; Owolabi, 2009). This familiarity-pleasure process has been explained with the hedonistic fluency hypothesis (Reber, Schwarz, & Winkielman, 2004).

## Hypothesized Relationships between Genes, Media Violence, and ADHD-Related Behaviors

When integrating the propositions of the disposition-content congruency hypothesis with earlier research findings on the heritability of media use and ADHD-related behaviors, four potential hypotheses emerge. These hypotheses are depicted in Figure 1. First, given the established heritability of ADHD (Faraone et al., 2005; Nikolas & Burt, 2010; Thapar et al., 2000), we hypothesize that children with a certain genetic disposition are more susceptible to ADHD-related behaviors compared to children with a different genetic disposition (H1).

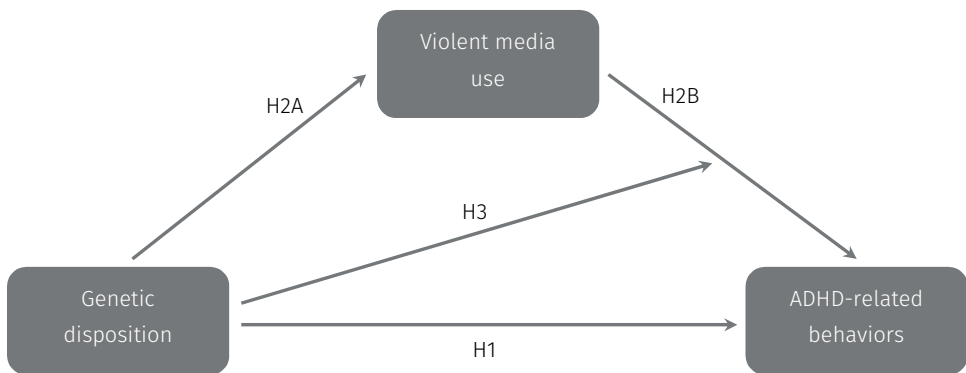
Second, we expect that children with a genetic susceptibility to ADHD-related behaviors will use more violent media (H2A). Children who display ADHD-related behaviors typically show low baseline levels of arousal (Beauchaine, Katkin, Strassberg, & Snarr, 2001; Lazzaro et al., 1999). Based on arousal theory (Eysenck, 1997), it is assumed that low baseline arousal leads children to seek out arousal-enhancing activities because low arousal is experienced as an unpleasant physiological state. Violent media use is an activity that can evoke intense arousal and therefore qualifies as a suitable arousal enhancer (Anderson & Bushman, 2001; Fleming & Rickwood, 2001). Our hypothesized relationship between genetic susceptibility and violent media exposure is an example of a phenomenon in the literature that has been named as *gene-environment correlation* (Rutter & Silberg, 2002).

Given the association between violent media use and ADHD-related behaviors found in earlier studies (Anderson & Maguire, 1978; Hastings et al., 2009; Kronenberger et al., 2005a; Levine & Waite, 2000; Zimmerman & Christakis, 2007), we expect that exposure to media violence may evoke ADHD-related behaviors (H2B). If H2A and H2B are valid, violent media use may act as a mediator between genetic disposition and ADHD-related behaviors, such that genetic disposition indirectly affects ADHD-related behaviors through its effect on violent media use (Hayes, 2009).

Our final hypothesis H3 concerns a moderating effect of children's genetic disposition on the relationship between violent media use and ADHD-related behaviors. Based on the disposition-content congruence hypothesis, we expect that children with a certain genetic disposition will be more vulnerable to influences of media violence compared to children with a different genetic disposition. Such a moderating effect of children's genetic disposition and environmental features (i.e., violent media exposure) is a conceptualization of a *gene-environment interaction* (Rutter & Silberg, 2002). This hypothesized relationship is visualized by path H3 in Figure 1.

In the disposition-content congruency hypothesis, the proposed mediating

and moderating effect of dispositional factors are expected to coincide. This implies that children with a genetic susceptibility to ADHD-related behaviors have a preference for violent media, and at the same time process violent media content differently than children without this genetic susceptibility, thereby strengthening its effect on ADHD-related behaviors. Such a model, in which a predictor of variable  $X$  is also the moderator of the effect of variable  $X$  on variable  $Y$ , is a conceptualization of a *moderated mediation* (Preacher, Rucker, & Hayes, 2007). Testing the joint occurrence of a mediating and moderating effect of genetic disposition in the relationship between violent media use and ADHD-related behaviors was the aim of this study.



**Figure 1** Disposition-content congruency hypothesis predicting the relationships between genetic disposition, violent media use, and ADHD-related behaviors.

### The 5-HTT Gene, Violent Media use, and ADHD

Although ADHD-related behaviors are highly heritable (e.g., Faraone et al., 2005), little is known about the specific genes that are involved. One gene that has been associated with ADHD is the 5-HTT gene (Manor et al., 2001; Zoroğlu et al., 2002). Previous gene-environment studies have shown a moderating effect of this gene on the relationship between aversive factors in the home environment (e.g., marital conflict) and children's ADHD-related behaviors (for an overview, see Nigg, Nikolas, & Burt, 2010). Given these earlier findings, the 5-HTT gene serves as a suitable candidate for testing our hypothesized model.

The 5-HTT gene plays a crucial role in regulating serotonin transmission in the brain (Greenberg et al., 1999). Serotonin is a neurotransmitter that has an important function in the regulation of emotions and impulses (Gazzaniga & Heatherton, 2006). Serotonin activity has been found to be involved in ADHD-related behaviors (Canli et al., 2005; Gainetdinov et al., 1999; Lucki, 1998). Within

the 5-HTT gene, a frequently studied polymorphism (i.e., part of the gene where the DNA code varies between individuals) is the 5-HTT-linked polymorphic region (5-HTTLPR). Traditionally, two alleles (i.e., variants) of this polymorphism are distinguished: a “short” (s) and a “long” (l) allele (Greenberg et al., 1999). The long allele of this polymorphism is usually found to be associated with ADHD-related behaviors (Manor et al., 2001; Zoroğlu et al., 2002). Therefore, we expect that the presence of the long allele of the 5-HTTLPR polymorphism will be associated with more ADHD-related behaviors (H1), and more violent media use (H2A). In addition, we expect that it will strengthen the relationship between violent media use and ADHD-related behaviors (H3).

## Method

### Sample

This study was conducted with a subsample of children participating in the 2010/2011 data wave of the *Generation R* study, a prospective longitudinal cohort study conducted in Rotterdam, the Netherlands. This subsample consisted of 1,612 children (51.1% male) aged 5 to 9 years ( $M = 6.00$ ,  $SD = 0.38$ ). Of the children in our sample, 59.6% were first-born children, 31.9% were second-born children, and 8.5% were third- or later-born children.

Our sample solely consisted of children of Dutch ethnicity to reduce possible effect variations of the 5-HTTLPR polymorphism due to ethnic heterogeneity. We defined Dutch ethnicity as having both parents and all four grandparents born in the Netherlands. Of the total group of 6,346 children participating in the 2010/2011 data wave of the *Generation R* study, 2,903 met this criterion. Of this subsample, 1,169 children were excluded because DNA samples were unavailable. Another 122 children were excluded due to incomplete survey data, resulting in a final sample of 1,612 children.

### Procedure

The *Generation R* study was designed to identify genetic and environmental factors contributing to the growth, health, and development of children, by following a large birth cohort from fetal life onwards (Jaddoe et al., 2012). Prenatal and postnatal assessment consisted of frequent physical examinations at child health centers and surveys filled out by the children’s parents. Regular assessment of the subjects continues until children reach young adulthood. The data for this study were obtained from DNA samples collected at birth and cross-sectional survey data collected at the 2010/2011 data wave. We tested our model using the most recent data wave of the *Generation R* study (the 2010/2011 wave), which is to

date the only wave in which our measure of violent media use has been included. Surveys were filled out by the children's primary caregiver (85.1% mother). The Generation R study has been approved by the Medical Ethical Committee of the Erasmus Medical Center, Rotterdam.

## Measures

**Genotyping.** DNA was extracted from umbilical cord blood samples collected at birth. Determination of the 5-HTTLPR polymorphism was carried out in a laboratory using common procedures.<sup>1</sup> The frequencies of the short (*s*) and long (*l*) alleles were 43.5 and 56.5%, respectively, indicating that the short variant was less frequently present in our sample than the long variant. This finding is in line with observations in other Caucasian samples (Brummett et al., 2008; Stein, Schork, & Gelernter, 2008). Each child had two copies of the 5-HTTLPR polymorphism (one copy from each parent), which combination is referred to as the child's genotype. Children's genotype could thus either consist of two *s* alleles (*s/s*), two *l* alleles (*l/l*), or one *s* and one *l* allele (*s/l*). To test for genotyping errors, we checked the distribution of the genotype frequencies in our sample (19.0% *s/s*, 49.0% *s/l*, and 32.1% *l/l*) against the Hardy-Weinberg equilibrium (HWE; Wigginton, Cutler, & Abecasis, 2005). The HWE is a principle predicting population genotype frequencies. Deviation from HWE might indicate problems in the genotyping process. The genotyping frequencies in our sample did not deviate from HWE,  $\chi^2(1) = .00, p = .969$ , indicating that the genotyping process was successful.

Besides distinguishing between the *s* and *l* allele, two subvariants of the long allele were distinguished, denoted by  $l_a$  and  $l_g$  (Nakamura, Ueno, Sano, & Tanabe, 2000). The frequencies of the  $l_a$  and  $l_g$  alleles were 49.4%, and 7.3% respectively. Because serotonin functioning of the  $l_g$  variant is comparable to that of the *s* allele (Nakamura et al., 2000) the *s* and  $l_g$  alleles were grouped together (denoted by *s'*). This resulted in a frequency distribution of 25.2%  $s'/s'$ , 51.1%  $s'/l_a$ , and 23.8%  $l_a/l_a$ . The 5-HTTLPR genotype was coded 0 =  $s'/s'$ , 1 =  $s'/l_a$ , 2 =  $l_a/l_a$ . The  $l_a$  allele indicates genetic susceptibility to ADHD-related behaviors (Manor et al., 2001; Zoroğlu et al., 2002).

**ADHD-related behaviors.** ADHD-related behaviors were measured using the DSM-ADHD subscale of the Child Behavior Checklist (CBCL; Achenbach & Rescorla,

<sup>1</sup> DNA was amplified by a standard polymerase chain reaction (PCR) procedure. Genotyping of the 5-HTTLPR polymorphism was done using Taqman allelic discrimination assay and genotyping master mix (Applied Biosystems, Foster City, CA). Two-step PCR using the GeneAmpR PCR system 9600 consisted of 10 minutes denaturation at 95 °C, following 40 cycles of 15 seconds denaturation at 96 °C and 90 seconds annealing-elongation at 62.5 °C. Signals were detected on the 7900HT Fast Real-Time PCR System (Applied Biosystems), and individual genotypes were determined using sequence detection system (SDS) software (version 2.3, Applied Biosystems).

2000).<sup>2</sup> This subscale has been especially constructed to be consistent with the diagnostic criteria of ADHD described in the DSM-IV. The subscale consists of six problem items, which mothers rated on a 3-point scale with 0 = *not true*, 1 = *somewhat or sometimes true*, 2 = *very true* of the child. Research has shown good convergent validity of this parent-report scale with clinician's ratings of ADHD (Nakamura, Ebesutani, Bernstein, & Chorpita, 2009). However, the CBCL's ADHD-scale is not designed to diagnose ADHD, nor does a high score on this scale necessarily indicate ADHD. Rather, it can be used as a continuous measure of the problem behaviors that are characteristic of ADHD, which is the aim of this study. The Dutch version of the CBCL has displayed good psychometric properties (Tick, van der Ende, Koot, & Verhulst, 2007). In our sample, Cronbach's alpha for this scale was .79 ( $M = 2.72$ ,  $SD = 2.48$ ).

**Violent media use.** Violent media use was measured using a scale specifically created for this study. This scale was based on commonly used time estimate measures of media use (Vandewater & Lee, 2009). Mothers indicated how often their child watched (a) television, (b) DVDs, and (c) videos and computer games in which violence occurs. Violence was defined as "all the violence (for example, fighting, shooting) that living beings (for example, people, monsters) do to each other." Response options were 1 = *never*, 2 = *one day a month*, 3 = *two days a month*, 4 = *three days a month*, 5 = *one day a week*, 6 = *two days a week*, 7 = *three days a week*, 8 = *four days a week*, 9 = *five days a week*, 10 = *six days a week*, and 11 = *every day*. Scores on the three items were summed to create a total violent media use score ( $M = 3.40$ ,  $SD = 4.71$ ).

**Covariates.** On the basis of previous studies, we included age (Valkenburg & Cantor, 2000), gender (Polanczyk et al., 2007), birth order (D'Onofrio et al., 2009; Satake, Yoshida, Yamashita, Kinukawa, & Takagishi, 2003), and socioeconomic status (SES; Zwirs et al., 2011) as covariates in our analyses. Children's age was measured in months. Gender was dichotomously scored as 0 = *male*, 1 = *female*. Birth order referred to the rank of the child by age amongst his or her older siblings, if any (0 = *first born*, 1 = *second born*, etc.). SES was a composite measure of mother's educational level, partner's educational level, and household income. Mother's and partner's educational level referred to the highest educational level they had finished, if any (0 = *no education finished*, 1 = *elementary education*, 2 = *lower secondary education*, 3 = *general or higher secondary education*, 4 = *vocational education*, 5 = *higher education*). Household income referred to the net income of the household per month, hence mother's income plus that of their partner, if any (1 = *less than 800 euros*, 2 = *800-1200 euros*, 3 = *1200-1600 euros*, 4 = *1600-2000 euros*, 7 = *2000-2400 euros*, 8 = *2400-3200 euros*, 9 = *3200-*

<sup>2</sup> We also ran the analyses with the "inattention" subscale of the CBCL and found the same results.

4000 euros, 10 = 4800-5600 euros, 11 = more than 5600 euros). Composite SES was calculated by averaging the standardized scores of mother's educational level, partner's educational level, and household income.

### Statistical Analysis

Our hypothesized model (Figure 1) was tested using the PROCESS SPSS macro developed by Hayes (2012). This macro uses linear regression analysis to test individual paths as well as indirect and moderated paths and produces bootstrap confidence intervals for testing the indirect effect. The bootstrap method has been described in detail elsewhere (Bollen & Stine, 1990). One of the advantages of using the bootstrapping technique is that it does not require the normality assumption to be met. It is therefore an appropriate method of testing effects in the presence of skewed data (Russel & Dean, 2000) as is the case with the data for this study. Five thousand bootstrap samples were drawn to generate bias-corrected and accelerated 95% confidence intervals (BCa 95% CI). All analyses controlled for gender, age, birth order, and SES.

## Results

### Zero-Order Correlations

Table 1 presents the zero-order correlations among the variables in our model. The correlations demonstrate that presence of the  $l_a$  allele of the 5-HTTLPR polymorphism was positively related to violent media exposure. Violent media exposure, in turn, was positively related to ADHD-related behaviors.

**Table 1** Correlations Among Violent Media Use, ADHD-Related Behaviors, the 5-HTTLPR Genotype, and Covariates

	Violent Media Use	ADHD-Related Behaviors
Main variables		
Violent media use		
ADHD-related behaviors	.08**	
5-HTTLPR genotype <sup>a</sup>	.07**	.00
Covariates		
Age	.09***	.01
Gender <sup>b</sup>	-.26***	-.10***
Birth order	.12***	-.15***
SES	-.01	-.23***

Note. <sup>a</sup>0 =  $s'/s'$ , 1 =  $s'/l_a'$ , 2 =  $l_a'/l_a'$ . <sup>b</sup>0 = boy, 1 = girl.

\*\*  $p < .01$ . \*\*\*  $p < .001$ .

## Testing the Model

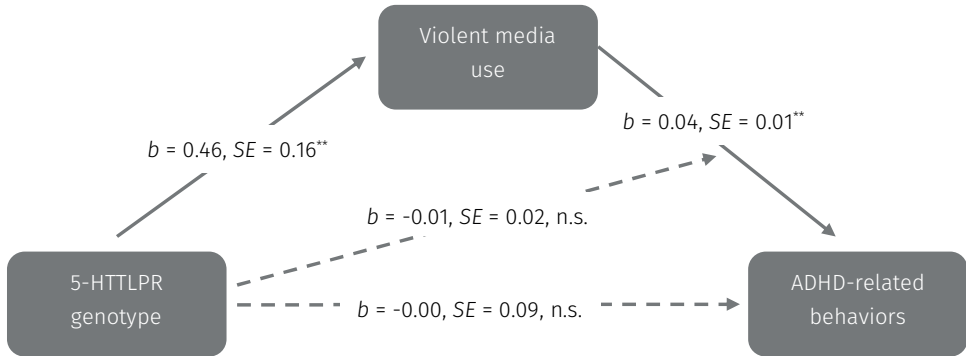
The test of our model (Figure 1) revealed no relationship between the 5-HTTLPR genotype and ADHD-related behaviors,  $b = -0.00$ ,  $SE = 0.09$ ,  $t = -0.03$ ,  $p = .978$ , rejecting H1. We did find a significant relationship between the 5-HTTLPR genotype and violent media use,  $b = 0.46$ ,  $SE = 0.16$ ,  $t = 2.87$ ,  $p = .004$ , supporting H2A. The relationship between violent media use and ADHD-related behaviors was also statistically significant,  $b = 0.04$ ,  $SE = 0.01$ ,  $t = 2.81$ ,  $p = .005$ , confirming H2B. Bootstrapping revealed that the indirect effect of the 5-HTTLPR genotype on the ADHD composite score through violent media use was statistically significant, with a standardized point estimate of .005 and a bias-corrected and accelerated 95% confidence interval (BCa 95% CI) of .001 to .011. Table 2 presents the results of the linear regression analyses without the interaction term. Inclusion of the interaction term revealed no moderating effect of the 5-HTTLPR genotype on the relationship between violent media use and ADHD-related behaviors,  $b = -0.01$ ,  $SE = 0.02$ ,  $t = -0.61$ ,  $p = .544$ . Therefore, H3 was not supported. Results of the analyses including the interaction term are graphically presented in Figure 2.<sup>3</sup>

**Table 2** Multiple Regression Analyses Predicting Violent Media Use and ADHD-Related Behaviors

	Violent Media use		ADHD-Related Behaviors	
	<i>b</i>	<i>SE b</i>	<i>b</i>	<i>SE b</i>
Age	0.08***	0.02	-0.01	0.01
Gender <sup>a</sup>	-2.53***	0.22	-0.37**	0.12
Birth order	0.84***	0.16	-0.48***	0.09
SES	-0.08	0.13	-0.64***	0.07
5-HTTLPR <sup>b</sup>	0.46**	0.16	-0.00	0.09
Violent media use			0.04**	0.01
<i>F</i>	34.82***		24.04***	
<i>R</i> <sup>2</sup>	0.10		0.08	

Note. <sup>a</sup>0 = boy, 1 = girl. <sup>b</sup>0 = *s*/*s*, 1 = *s*/*l*<sub>g</sub>, 2 = *l*<sub>g</sub>/*l*<sub>g</sub>.  
 \*\*  $p < .01$ . \*\*\*  $p < .001$ .

<sup>3</sup>We also tested our hypothesized model for the 7-repeat allele of the DRD4 gene, a gene important in the functioning of the dopaminergic system. No significant associations were found between the 7-repeat allele and violent media use or ADHD-related behaviors, rejecting our model for this gene.



**Figure 2** Linear regression results of the relationships between 5-HTTLPR genotype, violent media use, and ADHD-related behaviors. \*\*  $p < .01$

## Discussion

The main aim of this study was to extend previous research focusing on the relationship between violent media use and ADHD-related behaviors in children. Inspired by the disposition-content congruency model (Valkenburg & Peter, 2013), we investigated the role of genetic disposition (i.e., the 5-HTTLPR genotype) in the relationship between violent media use and ADHD-related behaviors. The model we tested is a conditional rather than a universal media effects model. It assumes that media effects do not equally hold for all children. It assumes that genetics play a role in both children's preference for violent media and their reaction to this content.

In H1, we predicted a direct association between the long allele of the 5-HTTLPR polymorphism and ADHD-related behaviors. This hypothesis could not be confirmed by our findings. Some previous studies, however, also failed to find such an association (Langley et al., 2003; Wigg et al., 2006). A possible explanation for this null-relationship may lie in our sampling methods. Many of the studies examining a direct relationship between specific gene variants and ADHD-related behaviors compared children clinically diagnosed with ADHD to "super-healthy" individuals (Kent et al., 2002; Manor et al., 2001; Seeger, Schloss, & Schmidt, 2001; Zoroğlu et al., 2002). In contrast, we studied a general population sample and measured ADHD-related behaviors as a continuous trait. Because the effects of single genes are typically very small (Plomin & Davis, 2009) they may only become significant when extreme groups are compared.

In H2A, we predicted a direct relationship between the 5-HTTLPR genotype and violent media use. The analyses supported our expectation. The presence

of the  $l_q$  variant was associated with more violent media use, indicating a gene-environment correlation. This finding extends previous studies that showed that overall media use is partly heritable (Kirzinger et al., 2012; Plomin et al., 1990), by showing a relationship between a specific gene and violent media use. As theorized by the disposition-content congruency hypothesis, our findings suggest that children, due to their genetic disposition, may *actively* seek specific media content (Harden, Hill, Turkheimer, & Emery, 2008; Rose, 2002), for example because they seek out arousing activities (Eysenck, 1997). However, an additional, *passive* process may also be in effect here. Parents share 50% of their DNA with their children and also shape the environment their children grow up in. Therefore, the association between children's genetic disposition and violent media use may also reflect the relationship between parents' genetic disposition and the environment they create for their children (Rutter & Silberg, 2002). Future research including genetic data from parents can help identify whether this association between genetic disposition and violent media exposure reflects active, passive, or both active and passive gene-environment correlations.

H2B concerned the relationship between violent media use and ADHD-related behaviors. We expected that children who were exposed to more media violence would display more ADHD-related behaviors compared to children who were exposed to less media violence. This expectation was confirmed by our findings. Although the effect was small, it does support findings from previous studies showing a positive relationship between violent media use and ADHD-related behaviors (Anderson & Maguire, 1978; Hastings et al., 2009; Kronenberger et al., 2005a; Levine & Waite, 2000; Zimmerman & Christakis, 2007).

Concerning the results of H1, H2A, and H2B, we performed an analysis to test for the indirect effect of the 5-HTTLPR genotype on ADHD-related behaviors. This analysis demonstrated that violent media use acted as a mediator within the relationship between the genotype and ADHD-related behaviors. Thus, in our sample, the 5-HTTLPR genotype did affect ADHD-related behaviors but only through its effect on violent media use. Especially in the absence of the direct effect of the genotype on ADHD-related behaviors (H1), this indirect relationship underlines the important role of violent media use in ADHD-related behaviors. Several earlier media-effects models, most notably the General Aggression Model (Anderson & Bushman, 2002) and the Reinforcing Spiral Model (Slater, 2007) have argued that media use should be seen as an endogenous variable, that is, the result of causally prior variables, including one's predisposition. These theories also argue that even when controlled for these prior variables, media use can change one's beliefs, attitudes, behavior, and personality characteristics (Anderson & Bushman, 2002; Slater, 2007; Valkenburg & Peter, 2013). Our study

has provided the first evidence for the proposition that violent media use should be conceptualized as a mediator between genetic disposition and ADHD-related behavior.

In our final hypothesis H3, we expected that the association between violent media use and ADHD-related behaviors would be dependent on children's 5-HTTLPR genotype. However, our results showed that the strength of the relationship between violent media use and ADHD-related behaviors did not vary between children as a function of their 5-HTTLPR genotype. Hence, there was no evidence of a gene-environment interaction between the child's genotype and violent media use, rejecting H3. Rutter and Silberg (2002) pose several explanations for why it is difficult to find such a gene-environment interaction effect. One explanation is that genes that moderate the effect of environmental factors (e.g., media violence) are not necessarily the same as the genes that have a main effect on behavior. In other words, susceptibility to media violence may be influenced by other genes than the 5-HTT gene. Another explanation is that finding a gene-environment interaction in the presence of gene-environment correlation may be problematic. Genetic and environmental factors are not independent, that is, genes may influence the environment. Therefore, it is difficult to entangle the interacting effect of the gene and the environment on behavior from the main effect of the gene (Rutter & Silberg, 2002).

### **Limitations and Future Research**

The results of this study are preliminary and require further validation. This study is the first to find an association between children's 5-HTTLPR genotype and violent media exposure, and, therefore, replication is needed. The data available in the Generation R study provided us with a unique opportunity to report on the relationship between the 5-HTT gene and the use and effects of media violence. However, the dataset did not allow us to test the cognitive or emotional processes that may underlie the relationship between violent media and ADHD-related behaviors. It is therefore an important goal of future research to investigate such underlying mechanisms, to be better able to explain the media-ADHD relationship.

In addition, because of its correlational nature, our study does not permit a conclusion about the direction of the relationship between violent media use and ADHD-related behaviors. Although it is often hypothesized that violent media cause ADHD-related behaviors in children, these children may also be more inclined to use violent media (Acevedo-Polakovich, Lorch, & Milich, 2007; Durkin, 2010). Future studies should thus examine the potential reciprocal relationship between violent media use and ADHD-related behaviors.

Finally, although little is known about the genetic structure of ADHD, several studies have identified other candidate genes that are linked to ADHD-related behaviors that could play a role in its relationship with media violence (Brookes et al., 2006; Gizer, 2009; Li, Sham, Owen, & He, 2006). One, for example, is the DRD4 gene, which is important in the functioning of the dopaminergic system. We also tested our model for the 7-repeat allele of the DRD4 gene, but found no significant effect in the relationship between violent media use and ADHD-related behaviors. Additional research on different genotypes is needed to establish reliable conclusions about the role of genes in the media-ADHD relationship.

## Conclusion

The results of this study provide some first insights into the disposition-content congruency hypothesis (Valkenburg & Peter, 2013). Although part of this hypothesis was rejected by our results (i.e., we did not find an interaction effect for the included genotype), our study can be an important starting point for media-effect researchers. It is often theorized that individual difference variables are important to include in models explaining media preferences and effects. However, such variables are still too often ignored, at least in the media-ADHD literature (Huizinga et al., 2013). The model we have tested in this study may not only be applied to genes but also to other individual difference variables in future research. In addition to dispositional variables, important individual difference variables may include developmental (e.g., cognitive level) and social variables (e.g., parents and peers; see Valkenburg & Peter, 2013).

The relationship between the 5-HTTLPR genotype and violent media use turned out to be small ( $r = .07$ ); even smaller than the effects sizes of media use on outcome variables typically found in media-effects research. Small genetic effects are not uncommon. Geneticists generally acknowledge that single-gene variants explain less than 1% of the variance in individual behavior (e.g., Comings et al., 2000). Such small effect sizes raise the question to what extent the inclusion of genetic data can enhance our understanding of media uses and effects. This is important to consider given that the inclusion of genetic data is costly. In our view, it is still important to pursue this new line of research. The developments in genetics are currently revolutionary, and the explanatory power of genetic predisposition is expected to increase significantly in the coming years. These developments may enhance our understanding of individual differences in the processing of environmental stimuli, including those encountered in the media. Several scholars have argued that we need to open up new horizons to understand how media affect their users (e.g., Nabi & Oliver, 2009; Sherry, 2004). In order to get a more elaborate understanding of media use, media processing,

and media effects, future research may benefit from incorporating insights from disciplines such as genetics and neurosciences. We hope that our study may form a first starting point for a more integrative approach to media effects research.

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# Chapter 4

## **Media violence and adolescents' ADHD-related behaviors: The role of parental mediation**

### **Abstract**

We examined the role of parental media mediation in the relationship between media violence and adolescents' ADHD-related behaviors. Survey data from 1,017 adolescents (10-14 years) show that parents can play an important role in this relationship, depending on the media mediation strategies that they use (i.e., restrictive or active mediation) and how they apply these strategies (i.e., in a controlling, inconsistent, or autonomy-supportive way). Our findings support the notion that contextual factors are critical in understanding media effects, and provide directions for how parents can manage their adolescents' violent media use, and possibly by extension, their ADHD-related behaviors.

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Attention-deficit/hyperactivity disorder (ADHD) is one of the most common childhood behavioral disorders, characterized by inattention, hyperactivity, and impulsivity (American Psychiatric Association, 2013), with a prevalence of around five percent in Western societies (Polanczyk, de Lima, Horta, Biederman, & Rohde, 2007). Associated risks include peer rejection, academic failure, and substance abuse (Willoughby, 2003), thereby posing a serious challenge to children, parents, teachers, and health care professionals. Although ADHD is clinically defined as a categorical disorder, most scholars agree that its core symptoms represent an underlying continuous distribution of behaviors (Lubke, Hudziak, Derks, van Bijsterveldt, & Boomsma, 2009). We adopt this view in the present study and refer to this continuum as *ADHD-related behaviors*.

It is often argued that frequent use of violent entertainment media (i.e., television and games) may contribute to the development of ADHD-related behaviors (Kronenberger et al., 2005; Levine & Waite, 2000; Zimmerman & Christakis, 2007). Indeed, a recent meta-analysis demonstrated a positive association between violent media use and ADHD-related behaviors ( $r = .12$ ; Nikkelen, Valkenburg, Huizinga, & Bushman, 2014). This relationship was small, but comparable to other research focusing on media use and behavior (see, for example, recent meta-analyses on media violence and aggression, Anderson et al., 2010; Greitemeyer & Muegge, 2014). However, although relationships between media use and behavior can be small for the majority, they may be large for particular individuals. Hence, media effects theories, such as the Differential Susceptibility to Media effects Model (DSMM, Valkenburg & Peter, 2013a), stress the importance of examining social context factors when looking at media-behavior relationships. The DSMM posits that social context factors may influence how much and what types of media children use as well as the effects of these media on children's behavior. As yet, research on social context variables that may influence the relationship between violent media use and ADHD-related behaviors is nearly non-existent.

Concerning violent media use, a particularly salient social context factor to consider is parental mediation, that is, the way parents handle their child's media use. Parents may set certain rules about what content their child uses (i.e., restrictive mediation) or may discuss media content with their child (i.e., active mediation, Valkenburg, Krccmar, Peeters, & Marseille, 1999). As such, parental mediation can be an important precursor of violent media use, as well as a moderator of its effects. Given the positive relationship between violent media use and ADHD-related behaviors (Nikkelen et al., 2014), it is essential to understand when and how parental mediation strategies can reduce or enhance violent media use and effects. Such findings can help inform public policy interventions designed to prevent or reduce children's behavioral problems. To this end, the aim of this

study is to investigate the role of parental mediation in the relationship between violent media use and ADHD-related behaviors in pre- and early adolescents (aged 10-14). We specifically focus on this age group because children's interest in violent content increases from pre- to early adolescence (Cantor, 1998), while in this age group parents still engage in parental mediation (Nikken, Jansz, & Schouwstra, 2007), which decreases later in adolescence.

### **Media Violence and ADHD-Related Behaviors**

There have been recurrent claims in the popular press as well as in scientific literature that television programs and video games are too violent in nature. Indeed, media entertainment frequently contains acts of violence (Bleakley, Jamieson, & Romer, 2012; Krahe, 2014), which has fueled a long-standing discussion about its potential harmful effect on children's aggression (see for example, Bushman & Huesmann, 2014; Elson & Ferguson, 2014). Recently, there has been an increasing interest in the question as to whether violent media use can elicit ADHD-related behaviors as well. This potential relationship is often explained through the violence-induced arousal habituation hypothesis, which posits that violent media use affects children's arousal functioning (Nikkelen et al., 2014). Research has shown that, initially, violent content elevates arousal levels (Anderson & Bushman, 2001). With frequent exposure, children's baseline arousal level is attenuated to adjust for this continuous high stimulation (e.g., Ballard, Hamby, Panee, & Nivens, 2006). Low baseline arousal, in turn, is often linked to ADHD-related behaviors (e.g., Nigg, 2006). An alternative hypothesis states that, after repeated violent media use, children develop an aggression script, which is characterized by poor self-control of behavior (Anderson & Bushman, 2001). Poor self-control, in turn, is argued to be a core feature underlying ADHD-related behaviors (Barkley, 1997).

Although a small positive relationship between violent media use and ADHD-related behaviors exists (Nikkelen et al., 2014), there is likely variability in children's susceptibility to violent media use and effects, resulting from factors within the family context (Valkenburg & Peter, 2013b). Family factors can play an important role in determining what media a child is exposed to and what effect this has on the child's behaviors (Jordan, 2004). One family factor that is repeatedly found to influence media use and effects is parental mediation (Buijzen, van der Molen, & Sondij, 2007; Nathanson, 2002; Van den Bulck & Van den Bergh, 2000). To our knowledge, no earlier study has investigated the role of parental mediation in the media-ADHD relationship, which is therefore the main aim of this study.

## Parental Media Mediation

Parental mediation refers to the strategies that parents employ to guide their child's media use. Two types of parental mediation are frequently distinguished: *restrictive* mediation (i.e., rule-setting to restrict media use) and *active* mediation (i.e., talking with children about media content, Nathanson, 1999; Valkenburg et al., 1999). In the literature, a distinction is often made between positive and negative active mediation (i.e., whether parents endorse or condemn the content in question, Nathanson, 2001a). In this study, we conceptualize active mediation as being critical of violent media content. Parental mediation can operate in two ways. First, parental mediation, and in particular restrictive mediation, can reduce media use (e.g., Van den Bulck & Van den Bergh, 2000). Second, mediation strategies can influence the effect that media has on children's behavior. Research on such moderating effects have focused mainly on the role of active mediation, and found that it can reduce potential harmful effects of media (e.g., Nathanson, 2004).

Parental mediation, however, does not always have the desired effect. Both restrictive and active mediation can be counter effective. For example, in one study, restriction of violent and sexual television content actually increased adolescents' viewing of this content with friends (Nathanson, 2002). In another study, active mediation was found to reduce the effect of violent media content on young children's positive attitudes towards the content, but enhanced positive attitudes in older children (Nathanson & Yang, 2003). Such 'boomerang' effects have prompted a call for closer examination of the conditions under which parental mediation is effective and when it is not (Chakroff & Nathanson, 2008). Accordingly, some researchers (Valkenburg, Piotrowski, Hermanns, & de Leeuw, 2013) have argued that it is important to understand not just whether parental mediation strategies occur but also the manner in which they are conveyed. To that end, Valkenburg et al. (2013) developed a scale to measure parental mediation (the Perceived Parental Media Mediation Scale, or PPMMS) in which they not only distinguish different types of parental mediation but also how these strategies are communicated to the child. The authors distinguish three common parenting styles, that is, controlling (i.e., using punishment or threat), inconsistent (i.e., being alternately strict and permissive), and autonomy-supportive parenting (i.e., being considerate of the child's perspective). Like parenting behaviors in general, the authors argue that parental mediation strategies may also be communicated to children in a controlling, inconsistent, or autonomy-supportive way. This is what sets the PPMMS apart from previous measures of parental mediation. Whereas previous scales have been designed to examine whether and to what extent parents use certain media mediation strategies (e.g., to what extent parents set

rules or are critical of certain content), the PPMMS was designed specifically to evaluate *how* parents convey these strategies.

Valkenburg et al. (2013) explain that when parents use a parenting style that is perceived by the child as a threat to their independence, this will elicit reactance. Reactance, in turn, increases the likelihood that adolescents will engage in the behavior that parents are trying to limit (Brehm & Brehm, 1981). Based on this concept of reactance, parental mediation is argued to be counter-effective when parents try to force their rules and opinions onto their child (i.e., using a controlling style). Inconsistent mediation is also argued to be counter-effective, as it is likely to induce reactance as well (Gardner, 1989). In particular, the short-term acquiescing and avoidance of conflict that is typical of inconsistent parenting reduces the likelihood that teens will conform to behavioral norms (Patterson, 1982). In contrast, parental mediation is considered effective when it is done in an autonomy-supportive way, such that the child's opinion is valued (Joussemet, Landry, & Koestner, 2008). Valkenburg et al. (2013) present several findings lending support to the argument that it is not whether parents engage in media mediation, but how parents engage in it that matters. Specifically, the authors showed that while controlling and inconsistent parental mediation were positively related to unfavorable behaviors (i.e., family conflict and aggression), autonomy-supportive mediation was negatively associated with these behaviors.

### **Parental Media Mediation, Media Violence, and ADHD-Related Behaviors**

The DSMM (Valkenburg & Peter, 2013a) offers a theoretical account for how parental mediation may influence the association between media violence and ADHD-related behaviors. This model posits that social context factors, including parenting behaviors, can influence media effects in two ways. First, parents may influence how much media children consume, as well as the specific content they are exposed to, which in turn can influence behavior. Second, parents may strengthen or weaken media effects by influencing their children's cognitive (e.g., attention), emotional (e.g., empathy), or excitative (e.g., arousal) responses to media. These responses are argued to be the underlying mechanisms in media-behavior relationships. Applying the DSMM to the violent media-ADHD relationship, there are two mechanisms by which parental mediation may play a role. First, it may directly influence how much violent media the child actually uses. This primarily pertains to *restrictive mediation*, which entails rule-setting to prevent or reduce particular media use. Second, parental mediation may moderate the relationship between violent media use and ADHD-related behaviors. This particularly pertains to *active mediation* because this mediation strategy is expected to influence children's responses to violent media content.

### **Restrictive parental media mediation model**

Concerning restrictive mediation, we expect that the way parents convey rules about violent media use will be related to the amount of violent media an adolescent uses. Consequently, these restrictive mediation styles may indirectly relate to an adolescent's ADHD-related behaviors, through their relationship with violent media use (see upper model in Figure 1). We expect that controlling restriction (i.e., getting angry and threatening to punish the child when he/she does not want to follow rules concerning violent media use) and inconsistent restriction (i.e., setting rules but not being consistent about enforcing them) are ineffective ways to reduce violent media use. In contrast, autonomy-supportive restriction (i.e., explaining why certain rules are set) is expected to be effective in reducing violent media use. We therefore formulate the following hypotheses:

H1: Controlling restriction will be related to more violent media use (H1a), and indirectly related to more ADHD-related behaviors (H1b).

H2: Inconsistent restriction will be related to more violent media use (H2a), and indirectly related to more ADHD-related behaviors (H2b).

H3: Autonomy-supportive restriction will be related to less violent media use (H3a), and indirectly related to less ADHD-related behaviors (H3b).

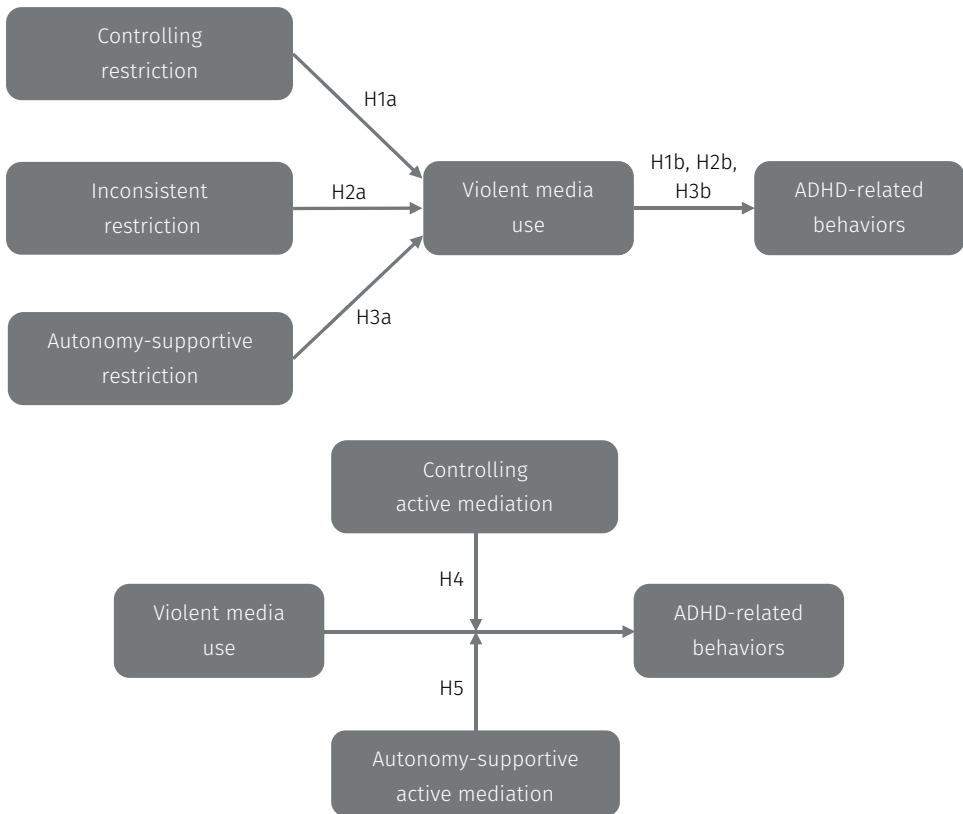
### **Active parental media mediation model**

With respect to active mediation, we expect that the style in which parents condemn or criticize violent media content can strengthen or weaken the relationship between adolescent's violent media use and ADHD-related behaviors (see lower model in Figure 1). As aforementioned, one of the reasons why violent media is argued to influence ADHD-related behaviors is by activating an aggressive script in the child (i.e., a cognitive response state, Valkenburg & Peter, 2013a). Criticizing violent content (e.g., saying that there is too much fighting in the media) may hinder children's formation of aggressive cognitive scripts by setting a negative norm about violent content. However, whether this is effective may depend on the parenting style that is used. Following Valkenburg et al. (2013), we expect that a controlling active mediation style (i.e., when parents condemn violent content in a stern way, without being open to the child's opinion), will be counter-effective in mitigating the effect of violent media use. In contrast, we expect an autonomy-supportive active mediation style (i.e., when parents condemn violent content, but are sensitive to the child's opinion) to be effective in mitigating violent media effects. Valkenburg et al. (2013) did not construct a

subscale to measure inconsistent active mediation. We therefore formulate the following hypotheses:

H4: Controlling active mediation will strengthen the relationship between violent media use and ADHD-related behaviors.

H5: Autonomy-supportive active mediation will weaken the relationship between violent media use and ADHD-related behaviors.



**Figure 1** Models hypothesizing indirect effect of restrictive mediation styles (upper) and moderating effect of active mediation styles (lower).

## Method

### Sample and Procedure

We analyzed survey data from 1,017 adolescents and one of their parents (79.0% mothers<sup>1</sup>). After receiving ethical approval, a private Dutch research company (TNS-NIPO/Veldkamp) collected the data between September and December 2012. Families were recruited through the research company's existing panel of approximately 60,000 nationally representative households. Because this study is part of a larger research design which required the inclusion of sibling data, the research company recruited 516 families with at least two adolescents between ten and fourteen years old. Two adolescents from each family participated, resulting in a total of 1,032 adolescents. Of these 1,032 adolescents, 3 were excluded due to missing parent surveys, and 12 due to missing adolescent surveys, leading to our final sample of 1,017 adolescents (49.9% female,  $M_{\text{age}} = 12.39$ ,  $SD_{\text{age}} = 1.38$ ), of which 99.9% sibling pairs. Adolescent-report questionnaires were used to measure violent media use and parental mediation. ADHD-related behaviors were measured using parent-report.

### Measures

**Parental media mediation.** To measure parental mediation, adolescents completed the 28-item Perceived Parental Media Mediation Scale (PPMMS, Valkenburg et al., 2013). Previous research has shown that children's self-report of parent mediation strategies better predicts behavior than parent-report (Fujioka & Austin, 2002; Gentile, Nathanson, Rasmussen, Reimer, & Walsh, 2012). For both restrictive and active mediation, four main questions asked about the frequency with which the type of mediation occurred (e.g., "How often do your parents forbid you from watching certain television shows or movies because they have too much violence in them?" [restrictive mediation] and "How often do your parents tell you that there is too much violence (fighting and shooting) in the media (for example in movies or games)?" [active mediation]). Responses ranged from 1 = *never* to 5 = *very often*. After each main item, follow-up items tapped into the different styles of parental mediation and were introduced with the question "And if your parents do/would do this, how would they discuss this with you?" The four main items measuring frequency of restrictive mediation were followed by three items (one for controlling, autonomy-supportive, and inconsistent restrictive mediation) and the four main items measuring frequency

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<sup>1</sup> The authors of the Dutch ADHD questionnaire (which was the only parent-report questionnaire in this study) report a high agreement between mothers and fathers on this scale (Scholte & Van der Ploeg, 2010). Therefore, we believe that the overrepresentation of mothers in our sample does not influence our results.

of active mediation were followed by two items (one for controlling and one for autonomy-supportive active mediation). Sample follow-up items are “They would get mad if I still want to watch these shows or movies” (controlling restriction) and “They would value their opinion more than mine” (controlling active mediation). Response options to these follow-up items ranged from 1 = *not true at all*, to 5 = *completely true*. The PPMMS has shown good reliability and validity (Valkenburg et al., 2013). For the purpose of the present study, we were only interested in the follow-up items measuring the styles of mediation. Scores on the four items for each mediation style were averaged to create measures of controlling restriction (CR;  $M = 1.95$ ,  $SD = 0.80$ ,  $\alpha = .74$ ), inconsistent restriction (IR;  $M = 2.08$ ,  $SD = 0.85$ ,  $\alpha = .79$ ), autonomy-supportive restriction (ASR;  $M = 3.35$ ,  $SD = 1.03$ ,  $\alpha = .83$ ), controlling active mediation (CAM;  $M = 2.45$ ,  $SD = 0.79$ ,  $\alpha = .70$ ), and autonomy-supportive active mediation (ASAM;  $M = 2.87$ ,  $SD = 0.97$ ,  $\alpha = .83$ ).

**Violent media use.** Violent media use was measured using direct estimates, which have been found reliable and valid for use in adolescent samples (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 gaming in hours per week. Subsequently, these two variables were summed to create one variable representing violent media use in hours per week ( $M = 5.48$ ,  $SD = 10.97$ ).

**ADHD-related behaviors.** To measure ADHD-related behaviors, parents filled out the Dutch ADHD questionnaire (Scholte & Van der Ploeg, 2010). It consists of 18 items, which 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). Items were rated on a five-point scale with 0 = *never*, 1 = *sometimes*, 2 = *regularly*, 3 = *often*, 4 = *very often*. A total ADHD-score was created by summing all 18 items ( $M = 15.82$ ,  $SD = 13.29$ ,  $\alpha = .94$ ). The mean score in our sample was similar to the mean score (i.e.,  $M = 14.80$ ,  $SD = 13.10$ ) in the Dutch population (Scholte & Van der Ploeg, 2010).

**Control variables.** Based on previous literature, our analyses controlled for adolescents' age, sex, and socio-economic status (SES). Violent media use increases with adolescents' age (Valkenburg & Cantor, 2001), whereas

ADHD-related behaviors tend to decrease (Biederman, Mick, & Faraone, 2000). Concerning sex, boys are typically more interested in violent content (Olson et al., 2007) and display more ADHD-related behaviors (Gershon & Gershon, 2002). SES is generally negatively associated with violent television use (SES, Gorely, Marshall, & Biddle, 2004) and children's behavior problems (Bradley & Corwyn, 2002). Age was measured in years. Sex was coded as 0 = *boy*, 1 = *girl*. SES was a composite of parents' educational level and household income. 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 averaging the standardized scores of educational level and household income.

### Statistical Analyses

To analyze the indirect effect of restrictive mediation (H1-H3), we used structural equation modeling (SEM). All variables were modeled as manifest indicators. We first tested the model including all covariance paths between the independent variables. Insignificant covariance paths were then deleted for reasons of parsimony. We evaluated model fit using the comparative fit index (CFI), the Tucker–Lewis fit index (TLI) and the root mean square error of approximation (RMSEA). CFI and TLI values between .90 and .95 and RMSEA values between .05 and .08 indicate acceptable model fit, and CFI and TLI values larger than .95 and RMSEA values smaller than .05 indicate good model fit (Fan, Thompson, & Wang, 1999). To test the moderation model for active mediation (H4 and H5), we conducted an OLS regression analysis. Independent variables were centered. All analyses controlled for age, sex, and SES.

The original violent media use variable was highly skewed, with a large group of respondents scoring close to zero. As this could potentially bias our results, we recoded the continuous measure of violent media use into five groups (0 [*0 hours*], 1 [*>0 - 2.5 hours*], 2 [*>2.5 - 7.5 hours*], 3 [*>7.5 - 20 hours*], 4 [*>20 hours*]), which more closely resembled a normal distribution ( $M = 1.46$ ,  $SD = 1.17$ ). All analyses included this recoded measure of violent media use.<sup>2</sup>

Analyses were conducted using STATA 12.1. We used robust clustering to correct for the clustered nature of our data (i.e., sibling data) and bootstrapping to account for skewness of our outcome variable (bias-corrected and accelerated 95% confidence intervals, 1,000 bootstrap samples). Before conducting the

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<sup>2</sup> Results were comparable when analyzing the models using the continuous measure of violent media use.

analyses, data were inspected for multivariate outliers using the Mahalanobis distance, which follows a chi-square distribution. Cases were considered outliers when their distance score exceeded the chi-square value at an alpha of .001 (Rousseeuw & Vanzomeren, 1990). One case was considered an outlier in the mediation model and two in the moderation model. Outliers were removed from the analyses.

## Results

### Bivariate Correlations

Table 1 displays the bivariate correlation coefficients among study variables. As expected, violent media use positively correlated with ADHD-related behaviors. Autonomy-supportive restriction was negatively associated with violent media use, whereas inconsistent restriction was positively associated with violent media use. Controlling restriction was not related to violent media use. From all mediation strategies, only inconsistent restriction was positively related to ADHD-related behaviors.

**Table 1** Bivariate Correlations among Study Variables

	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Media violence <sup>a</sup>									
2. ADHD	.16***								
3. CR	-.02	.05							
4. IR	.23***	.07*	.19***						
5. ASR	-.28***	-.04	.17***	-.10*					
6. CAM	-.02	.04	.42***	.24***	.18***				
7. ASAM	-.13***	-.06	.15***	-.02	.54***	.12***			
8. Sex <sup>b</sup>	-.44***	-.16***	-.06	-.10**	.18***	-.07*	.14***		
9. Age	.17***	-.06	.10**	.13***	-.02	.06	.08*	-.02	
10. SES	-.09**	-.03	.02	.00	.08**	.08*	.02	.02	-.02

*Note.* <sup>a</sup>Recoded in 5 groups. <sup>b</sup>0 = *boy*, 1 = *girl*. CR = controlling restriction; IR = inconsistent restriction; ASR = autonomy-supportive restriction; CAM = controlling active mediation; ASAM = autonomy-supportive active mediation.

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

### Restrictive Parental Media Mediation Model

Hypotheses 1-3 posited an indirect effect of restrictive media mediation styles on ADHD-related behaviors via violent media use. The final model<sup>3</sup> had good model fit, CFI = 1.00, TLI = 1.03, RMSEA = .00 (90% confidence interval [CI]: .00/.01)<sup>4</sup>. Results are illustrated in Figure 2<sup>5</sup>. Similar to the bivariate correlations, violent media use was positively related to ADHD-related behaviors,  $b^* = .12$ ,  $z = 2.90$ ,  $p = .004$ . Controlling restrictive mediation was negatively related to violent media use,  $b^* = -.06$ ,  $z = -2.04$ ,  $p = .041$ , rejecting H1a. When examining the indirect effect, we found no significant indirect relationship between controlling restriction and ADHD-related behaviors,  $b^* = -.01$ ,  $z = -1.75$ ,  $p = .081$ , rejecting H1b. Inconsistent restriction was positively related to violent media use,  $b^* = .16$ ,  $z = 5.45$ ,  $p < .001$ , and positively, indirectly related to ADHD-related behaviors,  $b^* = .02$ ,  $z = 2.56$ ,  $p = .010$ , supporting H2a and H2b. Lastly, autonomy-supportive restriction was negatively related to violent media use,  $b^* = -.17$ ,  $z = -5.71$ ,  $p < .001$ , consistent with H3a, and negatively, indirectly related to ADHD-related behaviors,  $b^* = -.02$ ,  $z = -2.62$ ,  $p = .009$ , supporting H3b.

### Active Parental Media Mediation Model

In H4 and H5, we expected that style of active mediation would moderate the relationship between violent media use and ADHD-related behaviors. The regression model (Wald  $\chi^2 = 46.82$ ,  $p < .001$ ,  $R^2 = .05$ ) did not support these hypotheses. There was no interaction between controlling active mediation and violent media use,  $b = -0.02$ ,  $SE = .09$ ,  $z = -0.28$ ,  $p = .778$ , nor between autonomy-supportive active mediation and violent media use on ADHD-related behaviors,  $b = -0.17$ ,  $SE = .40$ ,  $z = -0.42$ ,  $p = .677$ .

## Discussion

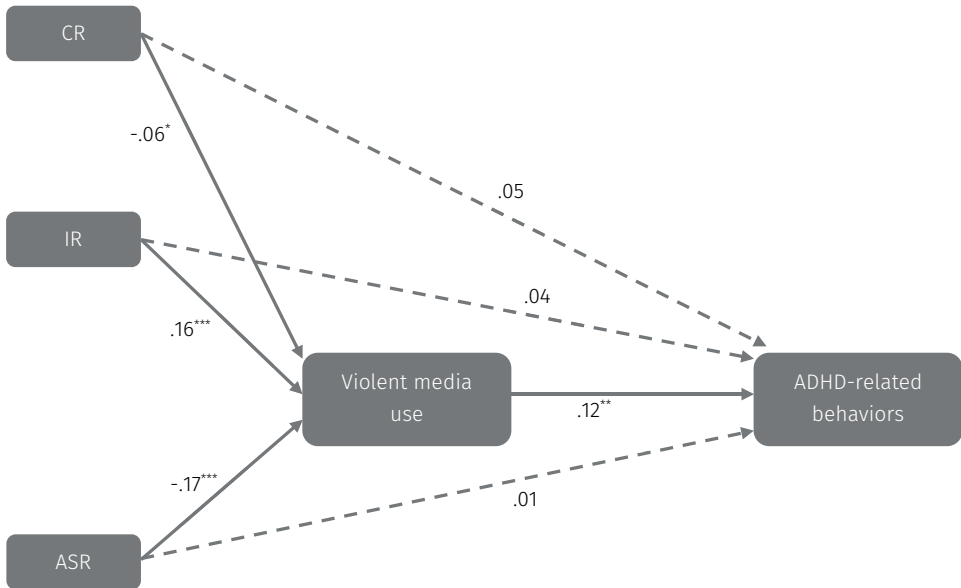
Previous studies indicate that violent media use may play a role in the development of ADHD-related behaviors. Given that current media effects theorizing would not expect this relationship to be true for all children, it is important to examine social context factors that determine which children may

<sup>3</sup>The following insignificant covariance paths were removed from the model: sex & age, sex & SES, age & SES, age & ASR, SES & IR, and SES & CR.

<sup>4</sup>STATA does not provide model fit for SEM models using robust clustering. Model fit was therefore obtained using MPLUS 7.2. However, because MPLUS cannot combine robust clustering and bootstrapping, the fit indices are reported for the model including robust clustering only.

<sup>5</sup>As previous research suggested that children with high ADHD-related behaviors may be more attracted to violent media content, we also tested the indirect effect with violent media use as outcome and ADHD-related behaviors as mediator and found no significant indirect effects for all three restrictive mediation styles.

be at particular risk for developing ADHD-related behaviors. To this end, the aim of this study was to examine the role of parental mediation in the relationship between violent media use and adolescents' ADHD-related behaviors. Our findings indicate that parents may play an important role in this relationship, depending on the media mediation strategies that they use and how they apply these strategies.



**Figure 2** Final structural equation model for the relationship between restrictive mediation styles, violent media use, and ADHD-related behaviors. Analysis controlled for age, sex and SES. Covariance paths are not displayed for reasons of clarity. Coefficients represent standardized betas. CR = controlling restriction; IR = inconsistent restriction; ASR = autonomy-supportive restriction. Indirect relationships with ADHD-related behaviors: CR:  $b^* = -.01$ ; IR:  $b^* = .02$ ; ASR:  $b^* = -.02^{**}$ .

### Restrictive Parental Media Mediation

We hypothesized that restrictive parental mediation would have a direct relationship with violent media use as well as an indirect relationship with adolescents' ADHD-related behaviors via violent media use. More specifically, we expected that controlling and inconsistent restrictive mediation would be

related to more violent media use (H1a and H2a) and indirectly related to more ADHD-related behaviors (H1b and H2b), while we expected autonomy-supportive restrictive mediation to be associated with less violent media use (H3a), and indirectly associated with fewer ADHD-related behaviors (H3b).

As predicted, we found that adolescents whose parents were more inconsistent in applying media rules consumed greater amounts of violent media and, in turn, displayed more ADHD-related behaviors. Also in line with our expectations, adolescents whose parents relied on more autonomy-supportive mediation practices consumed less violent media content and, in turn, displayed less ADHD-related behaviors. Controlling restrictive mediation, in contrast to our hypotheses, was related to less violent media use, and had no indirect relationship with ADHD-related behaviors. Like inconsistent restriction, controlling restriction is typically thought to induce reactance (e.g., Byrne & Lee, 2011) and was therefore expected to be associated with more violent media use. A possible reason for why we find evidence to support reactance with inconsistent parenting and not with controlling parenting may have to do with the cross-sectional nature of our data. Research suggests that controlling parenting is initially effective in reducing undesired behaviors (Baumrind, 1966; Lamborn, Mounts, Steinberg, & Dornbusch, 1991), but in the long term backfires and leads to resistance. In this study, we have only examined one point in time, and as such, this reactance may not yet have emerged. Future research replicating this study with longitudinal data in which the influence of parenting is investigated over time can provide valuable insight into whether the short-term benefits of controlling parenting do in fact reverse in the long-term.

### **Active Parental Media Mediation**

While restrictive mediation was expected to directly relate to violent media consumption, active parental mediation was expected to moderate the relationship between violent media use and ADHD-related behaviors. Specifically, controlling active mediation was expected to strengthen the relationship between violent media use and ADHD-related behaviors (H4), whereas autonomy-supportive active mediation was expected to weaken this relationship (H5). Our results did not provide evidence for these expectations; whether parents discussed harmful media content with their adolescent in a more controlling or in a more autonomy-supportive manner did not influence the relationship between violent media use and ADHD-related behaviors. These findings are somewhat surprising since previous studies have shown that active mediation can mitigate negative effects of violent media content (e.g., Nathanson, 2004).

A possible explanation for why we did not find a moderating effect of active

mediation may lie in the fact that active mediation is typically manipulated in experimental settings in which the mediation can be specifically tailored to the content under investigation (e.g., having the child focus on the feelings of the victim in aggressive scene, Nathanson & Cantor, 2000). Active mediation may be inherently more difficult to measure in a survey, which typically consists of more general questions. Another explanation may lie in the potential underlying mechanisms of the media violence – ADHD relationship. As outlined in the introduction, violent media may elicit ADHD-related behaviors by (1) activating aggressive scripts and/or (2) inducing high arousal. Active mediation was particularly expected to influence the formation and activation of aggressive scripts. Our null findings for active mediation might therefore suggest that the likely underlying mechanism in the media violence – ADHD relationship is not the aggressive-script pathway, but rather the arousal-inducing pathway, which may not be influenced by active mediation. At present, empirical evidence for the role of arousal (or other potential mechanisms) in the relationship between media violence and ADHD-related behaviors is lacking. Research examining these mechanisms is warranted, especially if we hope to understand how parental behavior can alter this relationship. For now, it is too early to dismiss the moderating role of active mediation, because our lack of findings may be specific to the media-ADHD relationship. Future studies should therefore try to replicate our findings with other outcome variables, such as aggression or prosocial behavior.

### **Implications and Directions for Future Research**

The results of this study have several important theoretical implications. First, our results confirm the previously found positive relationship between violent media use and ADHD-related behaviors. Although the relationship is small, the consistency of this finding across several studies and samples (i.e., Gentile, Swing, Lim, & Khoo, 2012; Kronenberger et al., 2005; Zimmerman & Christakis, 2007) is notable. Given the large role that media plays in the lives of adolescents, continued investigations into the relationship between media violence and ADHD-related behaviors are warranted. In particular, it is important to move beyond cross-sectional data to longitudinal data in order to better establish causal order. Although we theorized that parental mediation affects violent media use, it is conceivable that violent media use elicits certain parental mediation styles. If adolescents frequently consume violent media despite their parents' efforts to prevent or reduce this use, parents may be less likely to use autonomy-supportive strategies when setting rules about violent media use. Moreover, although it is often assumed that violent media use increases ADHD-related behaviors, it is

also possible that children who already display ADHD-related behaviors prefer arousal-inducing activities because of their low baseline arousal (Lazzaro et al., 1999). Using violent media content may be such an activity. Efforts to test these transactional relationships are critical if we hope to identify direction of effect.

Our findings provide support for investigating the role of social context factors in the relationship between media violence and ADHD-related behaviors. There are several other variables that would be relevant to consider. For example, in this study we specifically focused on mediation strategies that are intended at reducing the use or the effect of violent content. However, it may also be worthwhile to study the role of parent's modeling of violent behavior (i.e., being aggressive themselves), co-use of violent media (i.e., using violent media together), and positive mediation (i.e., endorsing violent content). Also, it may be valuable to examine the timing of mediation, as a recent experimental study suggests that mediation is most effective when it is done before or during media exposure, as opposed to mediation after exposure (Rasmussen, 2014). Another particularly fruitful area of investigation is the role of peers. Adolescence reflects a transition period during which the influence of the parent decreases while peer influence increases. Concerning media violence, peers may influence how much violent media an adolescent consumes via co-viewing (Nathanson, 2001b), and may accept or condemn the violent acts portrayed (Nathanson, 2001b). By highlighting the role of social context factors like these, future studies can provide a more comprehensive picture of the media violence–ADHD relationship.

Lastly, this study provides empirical evidence supporting the argument that the role of parental mediation is best understood by distinguishing not only the type of mediation strategies (i.e., active and restrictive) but also how these strategies are applied. In doing so, we are able to obtain a clearer idea of when and why certain mediation strategies are more effective than others, and thus provide parents with a clear message as to how to effectively manage media use in their household. This study, for example, suggests that parents interested in managing their teens' media violence consumption should approach rule-setting in an autonomy-supportive manner. This means explaining to teens why violent content may be inappropriate for them and respecting the teens' opinions in this process. In doing so, not only may violent media use be curbed, but this study suggests that it may also indirectly relate to adolescents' ADHD-related behaviors.

## **Conclusion**

Researchers have only begun to understand the relationship between media violence and ADHD-related behaviors. Our results suggest that parents can play a meaningful role in this relationship. In particular, the study points to the importance

of engaging in autonomy-supportive media restriction when managing teens' violent media consumption. This is an important finding as it not only supports the notion that contextual influences are critical in understanding media effects, but offers a suggestion for how parents can manage their adolescents' violent media use, and potentially by extension, adolescents' ADHD-related behaviors.

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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.<sup>1</sup> 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

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<sup>1</sup>In 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,  $M = -0.01$ ,  $SD = 0.88$ ).

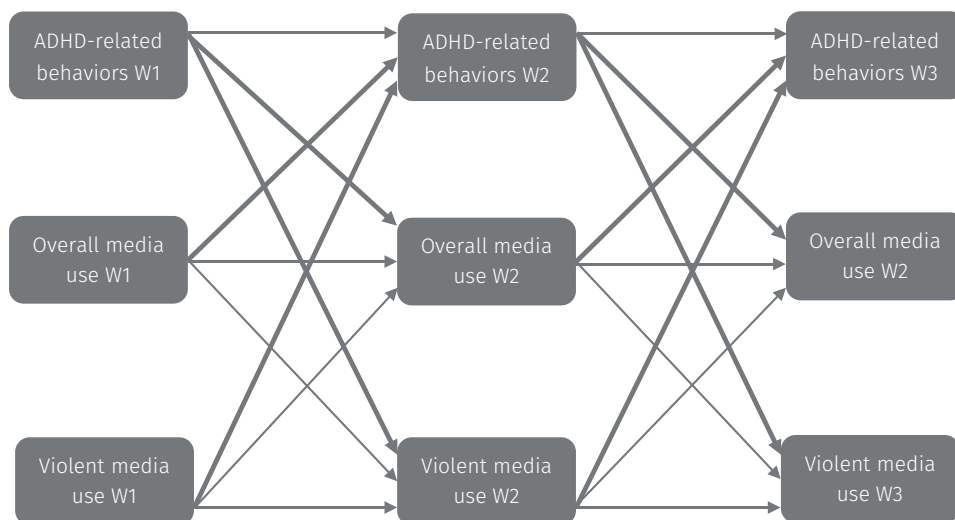
### Statistical Analyses

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 ( $\Delta\chi^2(8) = 8.48, p = .388$ ).

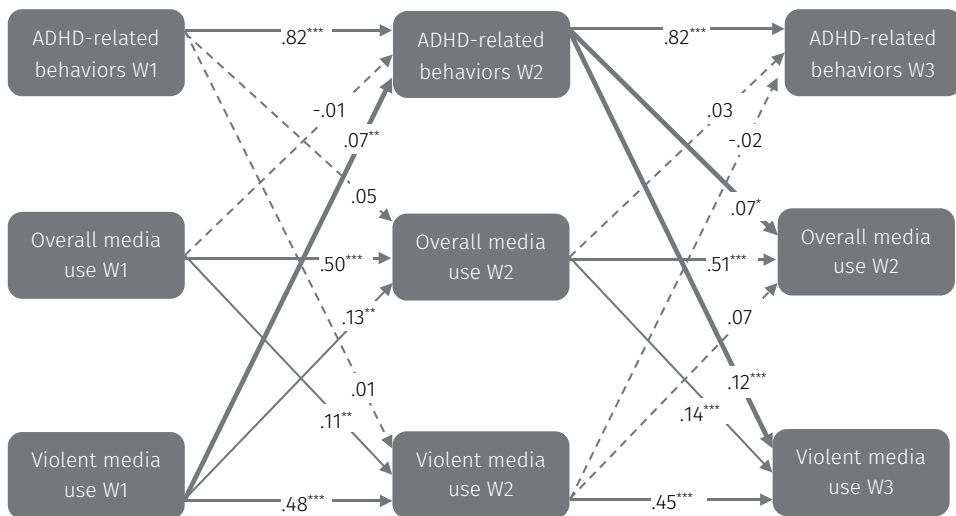
**Table 2** Bivariate Correlations among Media Variables, ADHD-related behaviors, and Covariates

		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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# General discussion

With the growing concern that entertainment media may elicit ADHD-related behaviors, it is critical that empirical research works to separate the fact from fiction accompanying this concern. Although studies on this topic have accumulated, the existing body of literature has not yet resulted in a clear image of how media and ADHD-related behaviors are associated. The objective of this dissertation was therefore to provide a detailed understanding of the role of entertainment media use in ADHD-related behaviors in children and adolescents. Guided by the Differential Susceptibility to Media effects Model (DSMM, Valkenburg & Peter, 2013a), this dissertation had three aims: (1) describing which media use behaviors are associated with ADHD-related behaviors, (2) investigating the role of individual difference factors in this association, and (3) examining causality in this relationship. In doing so, this dissertation extends existing theory and empirical knowledge into media use and ADHD-related behaviors. In short, although relationships were modest, the findings of this dissertation indicate that specifically children's consumption of violent media is of concern, as this can act both as a cause and as a consequence of ADHD-related behaviors. Moreover, in explaining why certain children use more violent media than others, both genetic disposition and parental mediation strategies were found to play an important role. In what follows, the main findings of this dissertation and its implications are discussed, as well as several important directions for future research.

### **Describing Differences in Media Use Behaviors Associated with ADHD-Related Behaviors**

Previous empirical studies into the relationship between media use and ADHD-related behaviors have yielded mixed findings (Kirkorian, Wartella, & Anderson, 2008): while some did find a link between media use and ADHD-related behaviors, other studies have rejected this finding. As such, it is unclear from previous literature whether or not media use and ADHD-related behaviors are associated and if so, whether this is specific to certain content or respondent samples. Therefore, Chapter 1 aimed to integrate and summarize the findings of the existing literature by means of a meta-analysis of 45 empirical studies into the media-ADHD relationship. Although relationships were small ( $r$ 's around .12), this meta-analysis showed that increased ADHD-related behaviors were associated with higher media use in general as well as with higher violent media use specifically. Moreover, the results show that study effects sizes increased as the percentage of boys in the sample increased, suggesting a stronger relationship between media use and ADHD-related behaviors for boys than for girls. Besides confirming the expectation that media use and ADHD-related behaviors are associated, Chapter 1 also demonstrated several important gaps in the current literature. For one thing,

it shows that the previous literature has mainly focused on children's general amount of media use or their violent media use. Few studies have examined children's use of other media content, such as educational content. Moreover, as the main focus of current literature has been on media exposure, little is known about potential differences in children's responses to media, such as their level of attention and arousal when using media.

Chapter 2 of this dissertation sought to address the aforementioned gaps in the literature by means of a comprehensive television diary study among 3-7 year-olds. The television diaries were used to measure general television use, specific content use (i.e., violent/scary and educational television content), and children's arousal and attention when watching television. In line with the meta-analysis, high ADHD-related behaviors were associated with more television viewing in general, and more viewing of violent/scary content, but only in boys. There were no differences in the amount of educational content viewing. However, children with high ADHD-related behaviors were less attentive when viewing educational content than children with low ADHD-related behaviors. This attention difference was not found when children watched violent/scary content. Lastly, high ADHD-related behaviors were associated with more arousal when viewing television, regardless of the content. Thus, next to replicating the earlier found differences in media use, Chapter 2 shows that ADHD-related behaviors are also associated with differences in attention and arousal when using media. Most importantly, the findings suggest that although educational content is specifically designed to grab and hold attention, these efforts may be less effective for children with high ADHD-related behaviors. Consequently, children with high ADHD-related behaviors may benefit less from educational content compared to their peers. This is worrisome given that these children often experience educational difficulties. For producers of educational content it may be important to think about how to design content that can also hold the attention children with high ADHD-related behaviors. Interestingly, these children were as attentive as their peers when viewing violent/scary content, which may indicate that these children are able to remain focused if the content is arousing. This, coupled with the finding that ADHD-related behaviors were associated with higher arousal when viewing television, provides some suggestion that arousal might play an underlying role in the media-ADHD relationship.

### **Individual Susceptibility in the Relationship Between Media Use and ADHD-Related Behaviors**

Another gap in the current literature that was identified in the meta-

analysis is that earlier research has mainly focused on the relationship between media use and ADHD-related behaviors in isolation, without taking the child's individual characteristics and social context into consideration. Yet, the DSMM posits that media use and media effects are not universal. Instead, it argues that individual differences can predict media use and can influence the strength of the relationship between media use and behavior. This dissertation explored several potential individual susceptibility factors. In Chapter 3, the role of genetic variability in the violent media-ADHD relationship was investigated. Specifically, this study focused on a gene variant which has been frequently associated with ADHD-related behaviors (the 5-HTTLPR polymorphism, Manor et al., 2001; Zoroğlu et al., 2002). It was found that variability in the 5-HTTLPR gene variant explained differences in children's amount of violent media use. In other words, children with a certain variation of this gene (the "long" variant) consumed a greater amount of violent media than children with a different variation (the "short" variant). Violent media use, in turn, was related to more ADHD-related behaviors. As such, this study shows that the 5-HTTLPR gene variant, which has previously been directly related to ADHD, also indirectly relates to children's ADHD-related behaviors via its relationship with violent media use. Although hypothesized in the DSMM, genetic variability did not strengthen nor weaken the violent media-ADHD relationship. In short, these findings indicate that children are not universally attracted to violent media use, but that this is in part genetically determined.

Where Chapter 3 investigated the influence of child characteristics in the violent media-ADHD relationship, Chapter 4 focused on a social context factor. Specifically, it examined the role of parental media mediation strategies, that is, how parents handle their child's media use. A distinction was made between different styles of *restrictive* mediation (i.e., how parents set rules about media use) and different styles of *active* mediation (i.e., how parents criticize violent content). For the restrictive mediation styles, their direct relationship with violent media use was investigated, and their indirect relationship with ADHD-related behaviors via violent media use. The findings indicate that parents, by the way they set rules about media use, can play a meaningful role in adolescent's amount of violent media consumption, and therefore, in their ADHD-related behaviors as well. Specifically, when parents set rules in an autonomy-supportive way (i.e., while being considerate of the child's perspective), adolescent consumed less violent media, whereas inconsistent rule-setting (i.e., not being persistent on these rules) was associated with more violent media use. Autonomy-supportive restrictive mediation thus seems effective, whereas inconsistent restrictions seems ineffective in regulating adolescents' violent media use. Further, this study examined whether active mediation styles moderated the relationship between

violent media use and ADHD-related behaviors. This was not the case: whether and how parents criticized violent content did not strengthen nor weaken this association. This was unexpected, given findings in earlier studies showing that active mediation can reduce the negative impact of violent media content (e.g., Nathanson, 2004). However, the null finding for active mediation in this study may actually fit well with the hypothesis that violent media use and ADHD-related behaviors are linked through arousal responses to media violence, which may be difficult to influence by parent's critique about the content.

Another individual difference factor that was examined throughout several studies in this dissertation is children's gender. In studies on the relationship between media and ADHD, gender is often included as a control variable since boys typically use more media in general and particularly more violent content (Valkenburg & Janssen, 1999) and display more ADHD-related behaviors (Willcutt, 2012). However, the meta-analysis discussed in Chapter 1 suggested that gender may also serve as a moderator, such that the relationship between media and ADHD-related behaviors would be stronger for boys than for girls. A moderation effect of gender was therefore directly investigated in Chapters 2 and 5. Chapter 2 indeed suggests that the positive relationship between ADHD-related behaviors and general and violent media use may especially exist in boys. However, no gender difference was found in the longitudinal study described in Chapter 5. One reason for this inconsistency in findings may have to do with sample differences. Chapter 2 was conducted among children in early childhood whereas Chapter 5 reports on an adolescent sample. Potentially, gender differences may emerge among children, but may disappear in adolescence. Although it is too early to draw conclusion about the role of gender in the media-ADHD relationship, the studies in this dissertation show that it is important to consider the possibility that the link between media use and ADHD-related behaviors may work differently for boys and girls.

### **Longitudinal Relationships Between Media Use and ADHD-Related Behaviors**

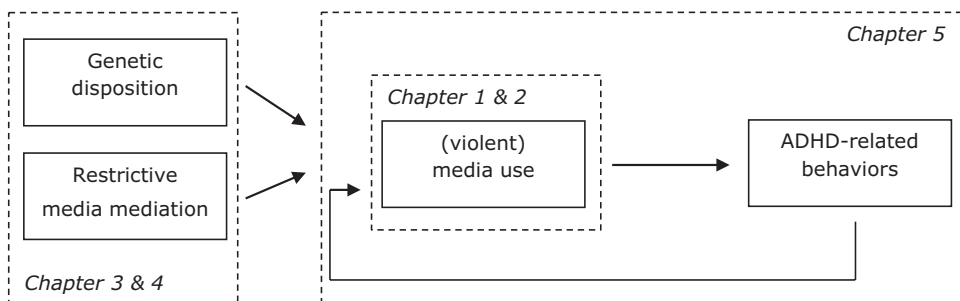
A final gap in the current literature, identified in Chapter 1, is that little is known about reciprocity in the media-ADHD relationship. Most longitudinal studies on the media-ADHD relationship have been conducted from a media effects perspective, focusing on the effect of media on behavior. However, the DSMM, as well as the reinforcing spirals model (Slater, 2007), posits that media use does not only influence behavior, but that behavior also influences media use itself (i.e., media selection). Therefore, by means of a three-wave cross-lagged study, Chapter 5 examined the longitudinal relationship between general and violent media use and ADHD-related behaviors. In general, this study confirmed

the cross-sectional correlations between (violent) media use and ADHD-related behaviors as found in Chapters 1 through 4. However, this study also showed that the longitudinal relationships were dependent on the content and the type of media use. Specifically, it was found that violent media use (television and games) can elicit ADHD-related behaviors among adolescents, and that ADHD-related behaviors, in turn, can predict violent media use. Adolescents' general media use (irrespective of content) did not predict subsequent ADHD-related behaviors. However, high ADHD-related behaviors did lead to increased media use, which could be attributed to increased gaming. The findings in this chapter support both the media effects and the media selection view on violent media use and ADHD-related behaviors. Thus, violent media may act both as a cause and as a consequence of ADHD-related behaviors, which suggests a negative cycle of effects between the two. General media use, specifically gaming, was only found to be a consequence of ADHD-related behaviors. These findings lend support to the argument that media effects on ADHD-related behaviors cannot be considered in isolation from media selection processes. Moreover, these results highlight that media use is not a unidimensional construct. Instead, they show that there are important content and medium differences in the relationship between media use and ADHD-related behaviors. The finding that only violent content (and not media use in general) elicited ADHD-related behaviors may be due to violent media content being especially arousing. Further, the findings suggest that children with high ADHD-related behaviors may be especially drawn to gaming rather than television viewing. Again, arousal may be driving this difference. Games are typically more active and interactive than television programs or movies and may therefore elicit more arousal. This may make it particularly attractive for children with high ADHD-related behaviors. The content and medium differences found in this chapter indicate that, when examining the role of media use in ADHD-related behaviors, careful consideration should be given as to how media use is conceptualized.

### **Putting the Pieces Together**

The three main conclusions that can be drawn from this dissertation are graphically represented in Figure 1. First, in general, all studies support the hypothesis that children's and adolescents' ADHD-related behaviors are associated with their media use, particularly their violent media use. Second, the findings suggest that violent media use is influenced by children's genetic variability and parent's restrictive media mediation styles. Third, there seems to be a reciprocal relationship between violent media use and ADHD-related behaviors.

Importantly, the five studies underline that the relationship between media use and ADHD-related behaviors is far more nuanced than what popular news headlines may suggest. For one thing, only violent media use (and not media use in general) predicted subsequent ADHD-related behaviors. Particularly noteworthy in this context is that the average amount of violent media use was not very high throughout the studies in this dissertation. This, however, may be specific to the Netherlands, the country in which the data was collected. Still, although the majority of children use little violent media, the small group of children who do consume a lot of violent media are of particular concern. Another nuancing factor is that effect sizes were small throughout the studies, which may indicate that the violent media-ADHD relationship mainly exists in certain vulnerable children, but may be negligible for the majority of children (Valkenburg & Peter, 2013b). For example, children who are already at risk for developing ADHD-related behaviors may be especially vulnerable to violent media effects on these behaviors. Common risk factors to consider in this, besides genetic disposition, are prenatal smoking, prematurity, and adverse family environments (Tarver, Daley, & Sayal, 2014). Thus, although parents should keep an eye on their children's violent media use, the results of this dissertation only partly justify the public concerns that are so often discussed in the popular press.



**Figure 1** Overview of main findings.

### Where To Go From Here?

Besides providing a detailed understanding of the relationship between media use and ADHD-related behaviors, this dissertation highlights several important avenues for future research. First, throughout the studies in this dissertation, it was hypothesized that arousal was the central underlying mechanism in the media-ADHD relationship. Arousal functioning was used to explain both why (violent) media use can elicit ADHD-related behaviors, and why children

with higher ADHD-related behaviors use more (violent) media. Although the findings of several chapters in this dissertation do suggest that arousal may be involved, no study to date has directly examined whether and how it mediates the longitudinal relationship between media use and ADHD-related behaviors. This calls for future research examining the underlying role of arousal in this association. This is not an easy task, for it may be difficult to measure children's arousal levels in real-life longitudinal designs. Arousal responses to media have been successfully measured in lab settings using physiological measures such as skin-conductance or heart-rate measures (Ballard & Wiest, 1996; Barlett, Harris, & Bruey, 2008; Barlett & Rodeheffer, 2009). To my knowledge, this has not been done yet while also including measures of ADHD-related behaviors, which would be a good place to start. However, the ecological validity of such lab studies is low and results may therefore not easily translate to real-life settings. This opts for analyzing arousal in real-life settings as well, for example using survey measures or observational measures. A potential shortcoming of such measures is that they may actually capture the behavioral manifestations of arousal instead of the child's internal arousal level. For example, low baseline arousal level may lead to restless behavior, in which case the reporter may indicate that the child's arousal level is high instead of low. Thus in future research examining the role of arousal in the media-ADHD relationship, a combined approach should be taken, employing several different measures of arousal in one longitudinal study.

Second, future studies are needed to disentangle the specific features of media that explain how media use can elicit ADHD-related behaviors and why certain content or medium types are especially attractive for children who display high ADHD-related behaviors. For example, if violent content is related to ADHD-related behaviors through the arousal elicited by the content, it is yet unclear whether the arousal-inducing effect can be attributed to the exciting narrative itself, its fast pace, or its frequent use of formal features. Further, the longitudinal study described in Chapter 5 showed that ADHD-related behaviors only affected overall gaming and not overall television viewing, which was argued to result from differences in interactivity and activity between these two media types, and hence in the level of arousal each elicits. However, activity and interactivity, as well as arousal level, were not directly measured. Although experimental studies suggest that playing a game elicits more arousal than watching television (Calvert & Tan, 1994; Lin, 2013), this has yet to be studied in the relationship with ADHD-related behaviors. These examples call for future studies that closely examine how and why specific media content and medium types are related to ADHD-related behaviors. Besides the aforementioned role of narrative, pacing, formal features, and (inter)activity, another potentially interesting factor in this is the

level of immersion (i.e., how much one feels physically present in the virtual world). Especially with the onset of new techniques such as 3D, immersion in television programs, movies, or games may be higher as ever, which is likely to influence the arousal that is elicited.

Third, further research is needed into other social context factors (i.e., besides parental media mediation) that may play a role in the relationship between media use and ADHD-related behaviors. After all, media use and ADHD-related behaviors do not occur in a vacuum. Instead, children grow up within a family and within a peer group, who are likely to influence children's media use, their behavior, or the relationship between media use and behavior (Valkenburg & Peter, 2013b). Family factors that are of potential interest are the media use of parents themselves and parent behavioral problems (e.g., parents' own ADHD-related behaviors), as these factors may provide particular norms, rules, and examples towards media use and behavior. In this respect, the media use of peers and their norms towards certain content or behaviors may also play an important role, especially for adolescents, who increasingly value the opinions of their peers. Another reason to focus on family and peer influences in future research is that such factors have been put forward as potential explanatory mechanisms in the media-ADHD relationship. For example, poor peer relationships and frequent parent-child conflict have both been argued to explain why children with high ADHD-related behaviors use more media in general (Acevedo-Polakovich, Lorch, & Milich, 2007).

Finally, more extensive longitudinal research is needed. The longitudinal study described in Chapter 5 only included three data waves, and exclusively focused on pre- and early adolescents. Although the five studies of this dissertation were conducted among samples of different age ranges, and consistently showed a relationship between media use and ADHD-related behaviors, the question remains how this relationship develops over the life course. More extensive longitudinal studies, including more data points and larger age ranges, could give more insight into this. Moreover, it could provide replication of and more details about the reciprocity between violent media use and ADHD-related behaviors. For example, studies could examine when the negative cycle between violent media use and ADHD-related behaviors starts and to what age it continues. Finally, such studies could shed more light on potential gender differences. As noted, there were inconsistencies between the different studies as to whether or not gender influences the media-ADHD relationship, which were attributed to differences in the ages of the samples, but this could not be directly assessed.

### **Implications for Parents and Healthcare Professionals**

The findings of this dissertation offer important practical implications for

parents and healthcare professionals. Although effect sizes were small, the chapters repeatedly show that there is a relationship between violent media use and ADHD-related behaviors, which was consistent over different samples (i.e., early and middle childhood and adolescence) and over time. The role of violent media use should therefore be considered in future ADHD prevention and treatment programs, especially because media is omnipresent in children's lives and takes up a large amount of their leisure time. Specifically, parents should be made aware of the potential effects of heavy violent media use on certain children's behavior. Further, parents may be stimulated to regulate their child's violent media use. The findings of this dissertation indicate that this may help to prevent ADHD-related behaviors or, if these behaviors are already present, that it may curtail the negative cycle between violent media use and ADHD-related behaviors. Specifically, parents can be instructed to consult media content ratings systems in order to obtain information about the content and the age-appropriateness of media productions. Examples are the Dutch 'Kijkwijzer' system, which provides ratings of television programs and movies, and the European 'PEGI' system providing game ratings. Both of these systems indicate whether or not certain productions contain violent content, and below which age the content may be harmful to the child. Rating systems like these are easy to use tools for parents to identify which content is more or less appropriate for their children. Guided by these rating systems, parents can be advised to set rules prohibiting their child from watching certain television productions or playing certain games. However, as indicated by the findings of this dissertation, it is important that parents are instructed to set these rules in an autonomy-supportive way, at least for adolescents. For example, for these rules to be effective, parents should explain why they set these rules and should ask about their teen's view on the matter, and show that they take their teen's opinion seriously. Healthcare professionals can play an important role in advising parents about potential harmful effects of heavy violent media use and about ways to regulate this use. Further, healthcare professionals may incorporate media use measures in their assessments of children displaying ADHD-related behaviors in order to evaluate whether violent media use is a factor that deserves attention in the treatment of these behaviors.

## **To Conclude**

The findings of this dissertation demonstrate that media use can, in fact, play a role in children's and adolescents' ADHD-related behaviors. However, they also highlight that this relationship should be considered with nuance because not all media content elicits ADHD-related behaviors. In particular, parents and healthcare professionals should be made aware of the potential harmful effects

of violent content. Since effect sizes were small, researchers should attempt to discover individual susceptibility factors that explain differences in media use and media effects on children's behavior. In doing so, children who are at particular risk for developing ADHD-related behaviors in response to (violent) media use may be identified early in the future. Together, the findings of this dissertation form an important step in unraveling the complex interplay between media use and ADHD-related behaviors.

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English summary

Recent decades have witnessed an increasing concern that excessive use of entertainment media (i.e., television programs and games) may elicit symptoms of attention-deficit/hyperactivity disorder (ADHD) in children. ADHD is a developmental disorder characterized by high levels of inattention (i.e., difficulties staying concentrated), hyperactivity (i.e., being restless), and impulsivity (i.e., problems inhibiting inappropriate behavior, American Psychiatric Association, 2013). ADHD is one of the most common childhood developmental disorders, with a prevalence ranging from 5.0 to 7.1% in Western countries (Willcutt, 2012). Simultaneously with the growing concerns, research on the potential relationship between media use and ADHD symptoms has accumulated. However, this has not yet resulted in a clear picture of this association. The goal of this dissertation is therefore to provide a detailed understanding of the media-ADHD relationship. Although ADHD is traditionally conceptualized as a clinical diagnostic disorder, it has been frequently argued that it is best viewed as a spectrum of behavioral problems (e.g., Larsson, Anckarsater, Råstam, Chang, & Lichtenstein, 2012). The studies in this dissertation employ this continuous view, and therefore, the term *ADHD-related behaviors* is used throughout.

Arguments for why media use and ADHD-related behaviors are likely to be associated center mainly around children's arousal functioning. It is frequently argued that the behaviors characteristic of ADHD are caused by a dysfunctional arousal system (Nigg, 2006; White, 1999). Also, use of entertainment media, particularly the use of exciting content, has been associated with elevations in arousal (Anderson & Bushman, 2001; Fleming & Rickwood, 2001). Applying these arousal hypotheses, there are two main roles media use may play in children's ADHD-related behaviors. First, from a media effects perspective, media use may contribute to the development of ADHD-related behaviors by affecting children's arousal functioning. Second, from a media selection perspective, the differences in arousal functioning between children with high and low ADHD-related behaviors may lead to different media preferences.

### **Dissertation Aims and Outline**

The aims of this dissertation are guided by three important gaps in previous literature. First of all, to be able to examine the media-ADHD relationship in close detail, it is essential to first have a thorough understanding of the specific media use behaviors that are associated with ADHD-related behaviors, that is, *what* media children use and *how* they respond when using it. This is unclear from previous literature and is therefore examined in the first part of this dissertation (**Chapters 1 and 2**).

Second, there has been little focus on individual differences in the media-ADHD

relationship. Current theoretical models, such as the Differential Susceptibility to Media effects Model (DSMM, Valkenburg & Peter, 2013a), posit that the relationship between media use and behavior is not universal. Instead, individual difference factors can directly influence media use (i.e., what media a child is exposed to) and can strengthen or weaken the effect of media use on behavior. Hence, it is crucial to investigate child and social context factors when examining media-behavior relationships. This is the aim of the second part of this dissertation (**Chapters 3 and 4**).

The third and final aim of this dissertation is to examine causality in the media-ADHD relationship. As aforementioned, there is argumentation for why media use may elicit ADHD-related behaviors, as well as for why ADHD-related behaviors may cause differences in media use. Both processes may also work simultaneously (Slater, 2007; Valkenburg & Peter, 2013a). However, most existing longitudinal studies on the media-ADHD relationship have been conducted from a media effects perspective and did not consider these reciprocal relationships. Those that did have resulted in different conclusions concerning causality (Gentile, Swing, Lim, & Khoo, 2012; Johnson, Cohen, Kasen, & Brook, 2007; Stevens, Barnard-Brak, & To, 2009). Therefore, the final chapter of this dissertation (**Chapter 5**) examines causality in the media-ADHD relationship.

## **Main Findings**

### **Part 1: Describing Differences in Media Use Behaviors**

#### *Chapter 1: Meta-analysis*

In Chapter 1 a quantitative meta-analysis was conducted of 45 empirical studies investigating the relationship between screen media use and ADHD-related behaviors in children and adolescents up to the age of 18. Although relationships were small ( $r$ 's around .12), this meta-analysis showed that increased ADHD-related behaviors were associated with higher media use in general as well as higher violent media use specifically. Moreover, the results suggest that study effects sizes increased as the percentage of boys in the sample increased, indicating stronger relationship between media use and ADHD-related behaviors for boys than for girls. Potential age differences were also explored, but no effect of age on the strength of the effect sizes emerged.

#### *Chapter 2: A television diary study of television use and responses*

Chapter 2 examined the relationship between ADHD-related behaviors and television viewing in general and specific content viewing (i.e., violent/scary and

educational) in young children (ages 3-7). Furthermore, it examined children's arousal and attention responses when viewing television. Finally, it investigated sex differences in all aforementioned relationships. To examine these relations, this study combined a survey with a comprehensive four-day television diary, filled out by children's parents ( $N = 865$ ). The television diary enabled a close examination of what content children actually watched and how they responded to that content. The results showed that high ADHD-related behaviors were associated with more overall viewing of television and more viewing of violent/scary content, but only in boys. ADHD-related behaviors were not related to educational content viewing. Furthermore, high ADHD-related behaviors were related to more arousal when viewing television, regardless of content. Finally, children with high ADHD-related behaviors showed less attention to overall and educational television, but showed no difference in attention level when watching violent or scary content.

## **Part 2: Individual Susceptibility**

### *Chapter 3: Genetic disposition*

Chapter 3 examined the role of children's genetic disposition in the relationship between violent media use and children's ADHD-related behaviors. Specifically, this study examined (1) whether genetic disposition is directly related to violent media use, and thereby indirectly related to ADHD-related behaviors, and (2) whether genetic disposition moderates the relationship between violent media use and ADHD-related behaviors. This study focused on a specific gene variant that has repeatedly been linked to ADHD: the 5-HTTLPR polymorphism. Using genetic data and parent-report surveys of 1,612 children (5-9 years), this study showed that a specific variation in the 5-HTTLPR polymorphism (the "long" variant) was related to higher violent media use, and indirectly related to ADHD-related behaviors via the relationship between the gene variation and violent media use. Variation in the gene did not moderate the relationship between violent media use and ADHD-related behaviors.

### *Chapter 4: Parental media mediation*

Chapter 4 focused on the role of parental media mediation in the relationship between media violence and ADHD-related behaviors in early adolescents (10-14 years,  $N = 1,017$ ). This study distinguished two commonly examined mediation strategies, namely restrictive mediation (i.e., rule-setting) and active mediation (criticizing violent media content), and how these strategies are communicated to the adolescent: in a controlling way (i.e., using punishment, threat, or shame), inconsistent way (i.e., being alternately strict and permissive), or

autonomy-supportive way (i.e., being encouraging and considerate of the child's perspective). Two models were tested, one for restrictive mediation, and one for active mediation. For restrictive mediation, the study examined whether the way in which parents set rules about media use was directly related to adolescents' violent media use and therefore indirectly related to adolescents' ADHD-related behaviors. For active mediation, the study investigated whether the way in which parents criticized violent content strengthened or weakened the violent media-ADHD relationship. The findings of this survey study indicated that parents play an important role in the relationship between violent media use and ADHD-related behaviors. This, however, depended on the media mediation strategies that parents used and how they applied these strategies. Specifically, the results showed that *inconsistent* restriction was associated with more violent media use, and indirectly associated with more ADHD-related behaviors through the relationship with violent media use. In contrast, *autonomy-supportive* restriction was related to less violent media use, and indirectly related to less ADHD-related behaviors. Results were less clear for controlling restriction. Finally, active mediation, in any form, did not strengthen nor weaken the violent media-ADHD relationship.

### **Part 3: Longitudinal Relationships**

#### *Chapter 5: A longitudinal study*

In the final chapter, a three-wave longitudinal study (with one-year intervals) among early adolescents (10-14 years old,  $N = 1,032$ ) was conducted. Using a cross-lagged panel design, the findings indicated that media use can both serve as a cause and as an effect of ADHD-related behaviors, depending on the content and the type of media use. Specifically, it was found that violent media use can elicit ADHD-related behaviors, and that ADHD-related behaviors, in turn, predicted violent media use. Adolescents' general amount of media use did not predict subsequent ADHD-related behaviors, but high ADHD-related behaviors did lead to increased media use. When distinguishing between medium, this latter effect appeared to be only true for overall game use, and not overall TV use.

### **Discussion**

The findings of this dissertation provide three important insights. First of all, the results show that there are specific differences in media use and media responses associated with ADHD-related behaviors. Consistently, the chapters show that children who display high ADHD-related behaviors use more media in general and specifically more exciting content, particularly violent content.

Moreover, Chapter 2 suggest that children with high ADHD-related behaviors also show differences in arousal and attention when exposed to media. Most importantly, the findings suggest that although educational content is specifically designed to grab and hold attention, these efforts may be less effective for children with high ADHD-related behaviors. Interestingly, these children were as attentive as their peers when viewing violent/scary content, which may indicate that these children are able to remain focused if the content is highly arousing. For producers of educational content it is therefore important to think about how to design content that can also hold the attention of children displaying high ADHD-related behaviors.

Second, this dissertation shows that individual difference factors can play an important role in the media-ADHD relationship. Chapter 3, which focused on the role of genetic variability, indicates that children are not universally attracted to violent media use, but that this is in part genetically determined. Thus, some children may be inherently more likely than others to be drawn to violent content, which subsequently may lead to increased ADHD-related behaviors. Chapter 4, which focused on parental mediation, argues that parents, by the way they set rules about media use, can play a meaningful role in adolescent's violent media consumption and as such, in adolescents' ADHD-related behaviors. Another individual difference factor that was examined throughout several studies in this dissertation is children's gender. Both chapter 1 and chapter 2 suggested that the relationship between media and ADHD-related behaviors would be stronger for boys than for girls. However, no such gender difference was found in the longitudinal study described in chapter 5. The potential role of gender thus warrants closer examination. Together, the findings of this dissertation highlight the importance of considering children's individual and context factors in the study of media use and ADHD-related behaviors.

Third, the findings of the longitudinal study argue that violent media acts both as a cause and as a consequence of ADHD-related behaviors, which suggests a negative cycle of effects between the two. General media use, however, was only found to be a consequence of ADHD-related behaviors. These findings therefore indicate that media effects on ADHD-related behaviors cannot be considered in isolation from media selection processes. These findings also indicate that media use is not a unidimensional construct, but that there are important content differences. Moreover, this chapter showed that differences between different types of media should be considered. Especially gaming, and not TV viewing, seems to be an attractive activity for children who display high ADHD-related behaviors. The aforementioned findings indicate that, when examining the role of media use in ADHD-related behaviors, the dynamic process between the two

should be taken into account and careful consideration should be given as to how media use is conceptualized.

In general, the findings of this dissertation only partly justify the public concerns about the role of media use in the development of ADHD-related behaviors, especially because only violent media use seems to predict ADHD-related behaviors, and not media use in general. In addition, it is noteworthy that the mean amount of violent media use was not particularly high throughout the studies in this dissertation. Still, although the majority of children use little violent media, the small group of children who do consume a great amount of violent media are of particular concern. In addition, effect sizes were small throughout the studies, which may indicate that the violent media-ADHD relationship mainly exists in certain vulnerable children, but may be negligible for the majority of children (Valkenburg & Peter, 2013b). For example, children who are already at risk for developing ADHD-related behaviors (for example because they have a genetic risk towards ADHD-related behaviors) may be especially vulnerable to violent media effects on these behaviors.

### **Directions for Future Research**

Besides providing a detailed understanding of the relationship between media use and ADHD-related behaviors, this dissertation highlights several avenues for future research. First, future research should focus on the role of arousal in the media-ADHD relationship. Although the findings of several chapters in this dissertation do suggest that arousal may be involved, no study to date has directly examined whether and how arousal mediates the longitudinal relationship between media use and ADHD-related behaviors. Second, future studies are needed to disentangle the specific features of media that explain how media use can elicit ADHD-related behaviors and why certain content or medium types are especially attractive for children who display high ADHD-related behaviors. For example, in the case arousal indeed underlies the relation between violent content and ADHD-related behaviors, it is yet unclear whether the arousal-inducing effect can be attributed to the exciting narrative itself, its fast pace, or its frequent use of formal features. Third, further research is needed into other social context factors that may play a role in the relationship between media use and ADHD-related behaviors. After all, media use and ADHD-related behaviors do not occur in a vacuum. Instead, children grow up within a family and within a peer group. By setting certain norms, standards, rules, and examples, family and peers are likely to influence children's media use, their behavior, or the relation between media use and behavior (Valkenburg & Peter, 2013b). Finally, more extensive longitudinal research is needed. The longitudinal study described

in chapter 5 only included three data waves, and exclusively focused on pre- and early adolescents. The question therefore remains how this relationship develops over the life course.

### **Implications for Parents and Healthcare Professionals**

The findings of this dissertation suggest that media use should be considered in future ADHD prevention and treatment programs. Although effect sizes were small, media use plays an important role in children's lives and is therefore a factor that should not be ignored. Specifically, parents should be made aware of the potential negative effect heavy violent media use can have on children's behavior. Further, they should be stimulated to regulate their child's violent media use. The findings of this dissertation indicate that this may help to prevent ADHD-related behaviors or, if these behaviors are already present, that it may curtail the negative cycle between violent media use and ADHD-related behaviors. Moreover, the findings also indicate that, for these rules to be effective, parents should set them in an autonomy-supportive way. Healthcare professionals can play an important role in advising parents about potential harmful effects of violent media use and about ways to regulate this use. Further, healthcare professionals may incorporate media use measures in their assessments of children displaying ADHD-related behaviors, to be able to evaluate whether violent media use is a factor that deserves attention in the treatment of these behaviors.

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# Dutch summary

(Nederlandse samenvatting)

De laatste decennia is er een toenemende zorg dat veelvuldig televisiekijken of gamen ADHD kan veroorzaken. ADHD (attention-deficit/hyperactivity disorder) is een ontwikkelingsstoornis, gekenmerkt door aandachtsproblemen (moeite met concentreren), hyperactiviteit (onrustig gedrag) en impulsiviteit (weinig zelfcontrole, American Psychiatric Association, 2013). ADHD komt in Westerse landen bij ongeveer vijf tot zeven procent van de kinderen voor en is daarmee één van de meest voorkomende gedragsproblemen (Willcutt, 2012). Met de genoemde zorgen over het verband tussen mediagebruik en ADHD is ook het wetenschappelijk onderzoek hiernaar toegenomen. Dit heeft echter tot voor kort niet geleid tot een duidelijk beeld van de samenhang tussen de twee. Het doel van dit proefschrift is daarom een gedetailleerd inzicht te geven in de rol van mediagebruik in ADHD.

Van oudsher wordt ADHD gezien als een klinische stoornis, met een scherpe grens tussen kinderen mét en zónder de stoornis. Tegenwoordig wordt echter vaak gesteld dat ADHD-symptomen beter te plaatsen zijn op een continuüm, variërend van geen tot ernstig probleemgedrag (Larsson, Anckarsater, Råstam, Chang, & Lichtenstein, 2012). De studies in dit proefschrift hanteren dit continuüm en gebruiken daarom de term *ADHD-gerelateerd gedrag*.

In theorieën die de relatie tussen mediagebruik en ADHD-gerelateerd gedrag verklaren speelt arousal vaak een centrale rol. De term arousal verwijst naar de mate van activatie van het zenuwstelsel, dat zich uit in verschillen in alertheid en opwinding (Humphreys & Revelle, 1984). ADHD-gerelateerd gedrag wordt vaak in verband gebracht met verstoringen in de regulatie van arousal (Nigg, 2006; White, 1999). Arousal is ook gelinkt aan mediagebruik: blootstelling aan audiovisuele media kan leiden tot een verhoogd arousal-niveau, zeker wanneer deze media een prikkelende of gewelddadige inhoud hebben (Anderson & Bushman, 2001; Fleming & Rickwood, 2001). Mediagebruik kan daarom op twee manieren in verband staan met ADHD-gerelateerd gedrag. Ten eerste kan mediagebruik ADHD-gerelateerd gedrag veroorzaken doordat het de arousal-regulatie van kinderen beïnvloedt (een media *effect*). Ten tweede kunnen de verschillen in arousal-regulatie tussen kinderen zorgen voor specifieke voorkeuren voor media (media *selectie*).

### **Focus en Opzet van dit Proefschrift**

Dit proefschrift focust op drie tekortkomingen in de bestaande wetenschappelijke literatuur. Ten eerste is nog onduidelijk welke specifieke mediagedragingen samenhangen met ADHD-gerelateerd gedrag. Kennis hierover is essentieel om de relatie tussen mediagebruik en ADHD-gerelateerd gedrag in meer detail te kunnen onderzoeken. Daarom wordt in het eerste deel van dit proefschrift onderzocht *welke* media kinderen gebruiken en *hoe* ze hierop

reageren (**Hoofdstuk 1 en 2**).

Ten tweede besteedt voorgaand onderzoek weinig aandacht aan individuele verschillen in de relatie tussen mediagebruik en ADHD-gerelateerd gedrag. Theoretische modellen, zoals het *Differential Susceptibility to Media effects Model* (DSMM, Valkenburg & Peter, 2013a), argumenteren dat deze relatie niet voor alle kinderen hetzelfde is. Individuele factoren kunnen leiden tot verschillen in mediagebruik (bijvoorbeeld aan welke media kinderen blootgesteld worden) en kunnen de relatie tussen mediagebruik en gedrag versterken of verzwakken. Het is daarom essentieel om factoren in het kind en binnen de sociale context te analyseren. Dit is de doelstelling van het tweede deel van dit proefschrift (**Hoofdstuk 3 en 4**).

De derde doelstelling van dit proefschrift is om de richting van het oorzakelijke verband tussen mediagebruik en ADHD-gerelateerd gedrag vast te stellen. Zoals eerder vermeld, zijn er zowel argumenten dat mediagebruik ADHD-gerelateerd gedrag veroorzaakt, alsook argumenten dat ADHD-gerelateerd gedrag leidt tot verschillen in mediagebruik. Beide processen kunnen ook tegelijkertijd actief zijn (Slater, 2007; Valkenburg & Peter, 2013a). Weinig longitudinale studies hebben echter beide processen overwogen. De studies die dit wel deden resulteerden in verschillende conclusies over de aanwezigheid van een verband tussen mediagebruik en ADHD-gerelateerd gedrag en wat hierin oorzaak en gevolg is (Gentile, Swing, Lim, & Khoo, 2012; Johnson, Cohen, Kasen, & Brook, 2007; Stevens, Barnard-Brak, & To, 2009). Het laatste hoofdstuk van dit proefschrift (**Hoofdstuk 5**) onderzoekt daarom het bestaan en de richting van een causale relatie tussen mediagebruik en ADHD-gerelateerd gedrag.

## Belangrijkste Bevindingen

### Deel 1: Beschrijven van Verschillen in Mediagebruik

#### *Hoofdstuk 1: Meta-analyse*

Hoofdstuk 1 doet verslag van een meta-analyse onder 45 studies die de relatie tussen mediagebruik en ADHD-gerelateerd gedrag onderzochten bij kinderen tot en met 18 jaar. Hoewel de verbanden klein waren, liet deze meta-analyse zien dat ADHD-gerelateerd gedrag samenhangt met meer mediagebruik in het algemeen en in het bijzonder met meer gebruik van gewelddadige media. Dit verband werd sterker naarmate het aandeel jongens toenam in de onderzoeksgroepen. Dit suggereert dat de relatie tussen mediagebruik en ADHD-gerelateerd gedrag sterker was voor jongens dan meisjes. Leeftijd bleek daarentegen geen effect te hebben op de sterkte van de verbanden.

### *Hoofdstuk 2: Een dagboekstudie naar televisiegebruik en –reacties*

Hoofdstuk 2 beschrijft een studie naar de relatie tussen ADHD-gerelateerd gedrag en het aantal uur dat kinderen televisie kijken en het kijken naar specifieke televisie-inhoud, zoals gewelddadige of educatieve programma's. Daarnaast werd de arousal en aandacht van kinderen tijdens het televisiekijken gemeten. Verder werden verschillen tussen jongens en meisje onderzocht. Om deze verbanden te onderzoeken werd een vragenlijst gecombineerd met een uitgebreid televisiedagboek, ingevuld door ouders van kinderen van 3 tot 7 jaar ( $N = 865$ ). De resultaten lieten zien dat ADHD-gerelateerd gedrag samenhang met meer televisie kijken en met meer blootstelling aan programma's met gewelddadige of angstwekkende inhoud. Dit gold echter alleen voor jongens. ADHD-gerelateerd gedrag hing niet samen met het kijken naar educatieve televisie programma's. Verder werd gevonden dat kinderen met meer ADHD-gerelateerd gedrag meer arousal lieten zien tijdens het televisiekijken, ongeacht de inhoud. Ten slotte bleek dat kinderen met veel ADHD-gerelateerd gedrag minder aandacht hadden voor educatieve televisieprogramma's dan hun leeftijdsgenootjes, maar dat ze even aandachtig naar gewelddadige of angstwekkende programma's keken.

## **Deel 2: Individuele Verschillen**

### *Hoofdstuk 3: Genetische aanleg*

In de studie die besproken wordt in Hoofdstuk 3 is onderzocht of genetische aanleg een rol speelt in de relatie tussen mediagebruik en ADHD-gerelateerd gedrag. Specifiek werd onderzocht of genetische verschillen tussen kinderen samenhangen met het gebruik van gewelddadige media en daarmee indirect met ADHD-gerelateerd gedrag. Ook werd bekeken of genetische verschillen de relatie tussen mediagebruik en ADHD-gerelateerd gedrag versterkte dan wel verzwakte. Deze studie richtte zich op een specifieke gen variatie die meermaals gelinkt is aan ADHD: de 5-HTTLPR gen variatie. Er werd gebruik gemaakt van genetische data en oudervragenlijsten van 1612 kinderen (5-9 jaar), afgenomen binnen het Generation R onderzoek. Deze studie liet zien dat een specifieke variant van de 5-HTTLPR (de 'lange' variant) samenhang met meer gebruik van gewelddadige media, en daarmee indirect samenhang met meer ADHD-gerelateerd gedrag. Variatie in de 5-HTTLPR had geen invloed op de sterkte van het verband tussen gewelddadig mediagebruik en ADHD-gerelateerd gedrag.

### *Hoofdstuk 4: Media mediatie door ouders*

Ouders kunnen verschillen in de strategieën die ze toepassen om het mediagebruik van hun kind te reguleren (media mediatie strategieën). Hoofdstuk

4 bespreekt een studie naar de rol van mediatiestrategieën in de relatie tussen gewelddadig mediagebruik en ADHD-gerelateerd gedrag in adolescenten (10-14 jaar,  $N = 1017$ ). Twee mediatiestrategieën werden onderzocht, namelijk restrictieve mediatie (het stellen van regels) en actieve mediatie (bekritisieren van media-inhoud). Daarnaast werd onderzocht hoe ouders deze strategieën overbrachten: op een straffende, inconsistente of autonomie-bevorderende manier. Voor restrictieve mediatie werd onderzocht of de manier waarop ouders regels stelden over mediagebruik direct samenhang met het gewelddadig mediagebruik van hun tiener, en daarmee indirect met hun ADHD-gerelateerd gedrag. Voor actieve mediatie werd onderzocht of de manier waarop ouders gewelddadige media inhoud bekritisieren de relatie tussen gewelddadig mediagebruik en ADHD-gerelateerd gedrag versterkt of verzwakt. Deze vragenlijststudie liet zien dat hoe inconsistenter ouders waren in het toepassen van regels over mediagebruik, hoe meer gewelddadige media tieners consumeerden en daarmee ook meer ADHD-gerelateerd gedrag lieten zien. Wanneer ouders echter op een meer autonomie-bevorderende manier regels stelden, was dit direct gerelateerd aan minder gewelddadig mediagebruik en indirect aan minder ADHD-gerelateerd gedrag. Actieve mediatie, ongeacht de manier waarop dit plaatsvond, had geen invloed op de sterkte van het verband tussen gewelddadig mediagebruik en ADHD-gerelateerd gedrag.

### **Deel 3: Longitudinale Verbanden**

#### *Hoofdstuk 5: Een longitudinale studie*

Het laatste hoofdstuk beschrijft een longitudinale studie met drie jaarlijkse meetmomenten, uitgevoerd onder 1032 adolescenten (10-14 jaar). De bevindingen van deze studie lieten zien dat mediagebruik zowel een oorzaak als een gevolg is van ADHD-gerelateerd gedrag, afhankelijk van het type en de inhoud van het mediagebruik. Hoewel veelvuldig mediagebruik niet leidde tot een toename in ADHD-gerelateerd gedrag, resulteerde een hoge mate van ADHD-gerelateerd gedrag wel in meer mediagebruik. Deze toename in het totale mediagebruik bleek alleen te bestaan voor gamen en niet voor televisiekijken. Wanneer naar specifieke inhoud gekeken werd, werd gevonden dat gewelddadig mediagebruik ADHD-gerelateerd gedrag veroorzaakte én dat ADHD-gerelateerd gedrag het gebruik van gewelddadig media deed toenemen. Dit gold voor zowel televisiekijken als gamen.

### **Discussie**

Dit proefschrift levert drie belangrijke inzichten op. Ten eerste laat het zien dat kinderen en jongeren die veel ADHD-gerelateerd gedrag vertonen verschillen van

hun leeftijdsgenoten in zowel hun mediagebruik als hun reacties op media-inhoud. Kinderen en jongeren met meer ADHD-gerelateerd gedrag besteden meer tijd aan audiovisuele media en gebruiken meer gewelddadige en angstwekkende media. Daarnaast suggereert Hoofdstuk 2 dat kinderen met veel ADHD-gerelateerd gedrag verschillen in hun aandachts- en hun arousal-niveau tijdens het televisiekijken. Hoewel educatieve media specifiek ontworpen zijn om de aandacht van kinderen te pakken en vast te houden, lijken zulke media minder goed te werken voor kinderen die ADHD-gerelateerd gedrag vertonen. Deze kinderen hadden immers minder aandacht voor educatieve televisieprogramma's dan kinderen met weinig ADHD-gerelateerd gedrag. Er was echter geen verschil in aandacht tussen kinderen wanneer ze naar gewelddadige of beangstigende programma's keken. Dit suggereert dat kinderen met veel ADHD-gerelateerd gedrag zich goed kunnen focussen als de inhoud prikkelend is. Voor makers van educatieve media is het daarom van belang na te denken over manieren om de concentratie van kinderen met veel ADHD-gerelateerd gedrag vast te houden.

Ten tweede laat dit proefschrift zien dat individuele factoren een belangrijke rol spelen in de relatie tussen mediagebruik en ADHD-gerelateerd gedrag. Hoofdstuk 3 suggereert dat kinderen zich niet in dezelfde mate aangetrokken voelen tot gewelddadige media, maar dat deze voorkeur deels genetisch is bepaald. In Hoofdstuk 4 lag de focus op mediatiestrategieën van ouders. De resultaten uit dit hoofdstuk laten zien dat ouders, door de manier waarop ze regels stellen over het mediagebruik van hun tiener, een belangrijke rol kunnen spelen in de hoeveelheid gewelddadige media die hun tieners consumeren. Daarmee kunnen ze mogelijk ook de mate van ADHD-gerelateerd gedrag van hun tiener beïnvloeden. Een andere individuele factor die onderzocht is in verschillende hoofdstukken is de sekse van het kind. De resultaten van zowel Hoofdstuk 1 als Hoofdstuk 2 suggereren dat het verband tussen mediagebruik en ADHD-gerelateerd gedrag sterker is voor jongens dan voor meisjes. Zulke sekseverschillen werden echter niet gevonden in Hoofdstuk 5. De rol van sekse dient daarom nog nader onderzocht te worden. Tezamen onderschrijven de resultaten van dit proefschrift het belang om individuele verschillen in het verband tussen mediagebruik en ADHD-gerelateerd gedrag te onderzoeken.

Ten derde impliceren de resultaten van Hoofdstuk 5 dat gebruik van *gewelddadige* media zowel een oorzaak als een gevolg van ADHD-gerelateerd gedrag kan zijn. Dit suggereert dat er een negatieve spiraal bestaat tussen de twee factoren. Wat betreft de *totale tijd* besteed aan media werd gevonden dat dit alleen een gevolg, en geen oorzaak, van ADHD-gerelateerd gedrag was. Dit geeft aan dat er onderscheid gemaakt moet worden tussen verschillende typen media-inhoud. Daarnaast liet dit hoofdstuk zien dat er rekening gehouden moet

worden met verschillende vormen van mediagebruik. Voornamelijk gamen lijkt een aantrekkelijke activiteit voor kinderen met veel ADHD-gerelateerd gedrag, en televisiekijken in mindere mate. Bovenstaande bevindingen benadrukken niet alleen het belang om het dynamische proces tussen mediagebruik en ADHD-gerelateerd te onderzoeken, maar ook om aandacht te besteden aan de verschillende typen media en media-inhoud die onderzocht worden.

De studies in dit proefschrift onderbouwen slechts gedeeltelijk de zorgen omtrent de invloed van mediagebruik op ADHD-gerelateerd gedrag. Met name omdat alleen gewelddadig mediagebruik ADHD-gerelateerd gedrag lijkt te verhogen, en niet mediagebruik als geheel. Hierbij is het belangrijk te vermelden dat het gebruik van gewelddadige media in geen van de studies zorgwekkend hoog was. Hoewel de meerderheid van de kinderen dus weinig gewelddadige media lijkt te gebruiken, moeten we vooral bezorgd zijn over de kleine groep kinderen die wel met veel gewelddadige media in aanraking komen. Daarnaast suggereren de relatief kleine effectgroottes in alle studies dat het effect van gewelddadig media op ADHD-gerelateerd gedrag vooral bestaat voor een groep kwetsbare kinderen (Valkenburg & Peter, 2013b). Zo zouden bijvoorbeeld kinderen die al een risico lopen op het ontwikkelen van ADHD-gerelateerd gedrag (bijvoorbeeld door hun genetische aanleg) extra vatbaar kunnen zijn voor de invloed van gewelddadige media inhoud.

### **Aanbevelingen voor Toekomstig Onderzoek**

Op basis van dit proefschrift kunnen een aantal aanbevelingen voor vervolgonderzoek worden gedaan. Ten eerste dient vervolgonderzoek zich te richten op de rol van arousal in de relatie tussen mediagebruik en ADHD-gerelateerd gedrag. Hoewel de resultaten van de studies suggereren dat arousal een rol kan spelen, is dit niet direct onderzocht. Verder kan vervolgonderzoek duidelijk maken welke specifieke kenmerken van media tot ADHD-gerelateerd gedrag kunnen leiden en waarom bepaalde media extra aantrekkelijk zijn voor kinderen die veel ADHD-gerelateerd gedrag vertonen. Wanneer arousal inderdaad de onderliggende oorzaak is, kan onderzoek duidelijk maken of de stijging in arousal veroorzaakt wordt door het opwindende verhaal, de snelheid, of door de grote hoeveelheid aan beeld- en geluidseffecten. Daarnaast moet worden onderzocht welke factoren binnen de sociale context van een kind een rol spelen in de relatie tussen mediagebruik en ADHD-gerelateerd gedrag. Mediagebruik en ADHD-gerelateerd gedrag vinden immers niet plaats in een vacuüm. Kinderen groeien op binnen een gezin en te midden van vrienden en klasgenoten. Doordat de omgeving bepaalde normen en standaarden heeft, is het aannemelijk dat dit invloed heeft op het mediagebruik en gedrag van het kind en mogelijk ook

op de relatie hiertussen (Valkenburg & Peter, 2013b). Tot slot is uitgebreider longitudinaal onderzoek nodig. De longitudinale studie in Hoofdstuk 5 besloeg slechts drie meetmomenten en richtte zich uitsluitend op adolescenten. De vraag blijft daarom hoe de relatie tussen mediagebruik en ADHD-gerelateerd gedrag zich ontwikkelt gedurende de levensloop.

### **Implicatie voor Ouders en Jeugdhulpverleners**

Dit proefschrift suggereert dat mediagebruik en ouderlijke mediatiestrategieën moeten worden meegenomen in behandelprogramma's gericht op het verminderen van ADHD-gerelateerd gedrag bij kinderen en adolescenten. Specifiek zouden ouders gestimuleerd kunnen worden het gebruik van gewelddadige media van hun kinderen te reguleren, omdat, zoals dit proefschrift laat zien, dit de ontwikkeling van ADHD-gerelateerd gedrag kan helpen voorkomen. Regels over mediagebruik blijken, zoals dit proefschrift laat zien, echter alleen effectief wanneer deze op een autonomie-bevorderende manier gesteld worden. Hulpverleners kunnen een belangrijke rol spelen bij het adviseren van ouders over de juiste strategieën om het gebruik van gewelddadige media te reguleren en zo mogelijk negatieve effecten ervan tegen te gaan.

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# Author contributions

## Authors' initials

S.W.C. Nikkelen – SN; H.G.M. Vossen – HV; P.M. Valkenburg – PV; J.T. Piotrowski – JP; M. Huizinga – MH; B.J. Bushman – BB; F.P. Velders – FV; D.A. Windhorst, – DW; V.W.V. Jaddoe – VJ; A. Hofman – AH; F.C. Verhulst – FV; H. Tiemeier – HT.

## CHAPTER 1

**Media Use and ADHD-Related Behaviors in Children and Adolescents: A Meta-Analysis. Nikkelen, S. W. C., Valkenburg, P. M., Huizinga, M., & Bushman, B. J.**

Author SN had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: SN, PV, and MH. Data acquisition and analysis: SN. Data interpretation: SN and BB. Drafting of the manuscript: SN, PV, and MH. Critical revision of the manuscript for important intellectual content: BB.

## CHAPTER 2

**Children's Television Viewing and ADHD-related Behaviors: Evidence from the Netherlands. Nikkelen, S. W. C., Vossen, H. G. M., & Valkenburg, P. M.**

Author SN had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: SN, HV, and PV. Data analysis and interpretation: SN and HV. Drafting of the manuscript: SN, HV, and PV. All authors read, edited and approved the final manuscript.

## CHAPTER 3

**Media violence and children's ADHD-related behaviors: A genetic susceptibility perspective. Nikkelen, S. W. C., Vossen, H. G. M., Valkenburg, P. M., Velders, F. P., Windhorst, D. A., Jaddoe, V. W. V., Hofman, A., Verhulst, F. C., Tiemeier, H.**

Author SN had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: SN, HV, and PV. Data analysis and interpretation: SN and HV. Drafting of the manuscript: SN, HV, and PV. Data collection and ownership: FV, DW, VJ, AH, FV, HT. All authors read, edited and approved the final manuscript.

#### CHAPTER 4

##### **Media violence and adolescents' ADHD-related behaviors: The role of parental mediation. Nikkelen, S. W. C., Vossen, H. G. M., Piotrowski, J. T. & Valkenburg, P. M.**

Author SN had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: SN, HV, JP, and PV. Data analysis and interpretation: SN and HV. Drafting of the manuscript: SN, HV, JP, and PV. All authors read, edited and approved the final manuscript.

#### CHAPTER 5

##### **Examining bi-directional longitudinal relationships between adolescents' media use and ADHD-related behaviors. Nikkelen, S. W. C., Vossen, H. G. M., Piotrowski, J. T. & Valkenburg, P. M.**

Author SN had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: SN, HV, JP, and PV. Data analysis and interpretation: SN and HV. Drafting of the manuscript: SN, HV, JP, and PV. All authors read, edited and approved the final manuscript.

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## **Curriculum vitae**

Sanne Nikkelen was born on the 1<sup>st</sup> of January 1987 in Wijchen, the Netherlands. After finishing secondary education (gymnasium) at Dominicus College in Nijmegen, she studied pedagogical science at Radboud University in Nijmegen. After obtaining her bachelor's degree in 2008, she did a two-year research master's program in behavioral science at the same university. Her master thesis focused on the role of media use in body dissatisfaction among men. She obtained her research master's degree in 2010, after which she started as a PhD candidate at the Amsterdam School of Communication Research (ASCoR), at the University of Amsterdam. Under supervision of prof. dr. Patti Valkenburg, dr. Helen Vossen, and dr. Jessica Piotrowski, she conducted the research that is described in this thesis. She currently works as a researcher at Rutgers, the Dutch centre of expertise on sexual and reproductive health and rights in Utrecht, the Netherlands.