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2018

The Influence Of Television Pacing On Attention And Executive Functioning

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THE INFLUENCE OF TELEVISION PACING ON ATTENTION AND EXECUTIVE FUNCTIONING

A Dissertation Presented

by

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to

The Faculty of the Graduate College

of

The University of Vermont

In Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy
Specializing in Psychology

October, 2017

Defense Date: August 28, 2017
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Abstract

Television shows, especially cartoons, are one of the most common types of media in children's lives. Although there is a well-established connection between television exposure and difficulties with attention, it is unclear if all types of television are equally impactful. Given the amount of time children are exposed to television, there is a need to better understand which components of shows may or may not impact one's attentional and executive functioning abilities. One such factor is the pace of the content. The current study expands on this limited area of the literature by utilizing a 9-minute 30-second long cartoon video, which has been edited at both a fast and slow pace, to examine the influence of pace on measures of attention and executive functioning (the Stop Signal Task and the Attentional Network Test) in both Typically Developing children (N = 24) and children with Attention-Deficit/Hyperactivity Disorder (ADHD; N = 17). Two (group; children with ADHD vs. Typically Developing children) x two (pace; fast vs. slow) ANCOVAs were conducted separately with each outcome measure as the dependent variable, group (ADHD and Typically Developing) and pace (fast and slow) as the independent variables, and IQ and Internalizing Problems as covariates. Findings suggested that although the majority of results were non-significant, effect sizes for group and pace (and associated covariates) varied across outcome measures. The Alerting and Executive Control ANT Networks also had non-significant but small effect sizes for the group by pace interactions. Planned comparisons of estimated marginal means revealed a non-significant and small effect of pace for children with ADHD, but no effect for Typically Developing children, for both interactions. Implications for those who work with and care for children are reviewed, and study limitations and future research directions are discussed.

Acknowledgements

I am incredibly grateful to those who have guided, encouraged, and inspired me throughout this project, my graduate education in psychology, and my education in general.

Specifically, I would like to thank my mentor, Rob Althoff, for his support throughout this project. From the day I first pitched the idea through the entire writing process, he has been an invaluable resource who has always found this topic as fun as I have. Additionally, I am indebted to Hannah Frering for her incredible project coordination skills. Further, I appreciate the guidance and feedback provided by my committee members: Tiffany Hutchins, Annie Murray-Close, Alexi Potter, and Rex Forehand (who has been a beacon of support throughout my time at UVM).

The psychology graduate students at UVM are a wonderful and witty bunch who foster a collegial and collaborative environment. I am particularly appreciative of those who provided voices & story ideas for the video at the heart of this project and edits & revisions to the manuscript: Andrew Gill, Sheau-Yan Ho, Elyse Rosenberg, Meghan Schreck, and Jeff Winer.

Above all, I am grateful for the endless support and encouragement of my family: my brother, who cannot believe I am still in school; my grandfather, who introduced me to the importance of a good story; and most of all, my parents. Gail and Bill, thank you for providing such wonderful guidance and support throughout my education – and my entire life.

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Introduction

Over the last century, visual media has become almost ever-present in American society. This societal change has been quite rapid, from the development of movie studios in California at the beginning of the 20^{th} century (Sklar, 2012), to the proliferation of television sets into almost every household in the mid-20^{th} century (Edgerton, 2009), and, most recently, to the omnipresence of laptops, smartphones and tablet computers providing entertainment at any time and in any location (Smith, 2010; Smith, 2013; Zickuhr, 2013). Thus, Americans, and especially American children, have been bombarded by motion pictures at an increasing pace over the last century.

Additionally, while movies, television shows, and YouTube videos have proliferated across the landscape over the last several decades, there has also been an increased awareness of mental health – especially for children. One of the most studied, and indeed the most prevalent, childhood disorders is Attention-Deficit/Hyperactivity Disorder (ADHD) (Polanczyk, Willcutt, Salum, Kieling, & Rohde, 2014; Wolraich, 1999). A connection has been drawn between difficulties with attention (a key component of ADHD) and exposure to television. Although the data suggest negative associations between increased television exposure and attentional abilities (Christakis, Zimmerman, DiGiuseppe, & McCarty, 2004; Landhuis, Poulton, Welch, & Hancox, 2007), it is not clear if all types of programming have an equal impact on attention (Kostyrka-Allchorne, Cooper, & Simpson, 2017). There are multiple factors of television exposure - amount, content, and structure, among others - that may or may not affect attention. One of these factors, which has been relatively under-studied, focuses on the effect of the *pace* of television shows on symptoms of ADHD and executive function

(Nikkelen, Valkenburg, Huizinga, & Bushman, 2014). Of note, the work performed to date examining pace has contained a range of conceptual and/or methodological flaws, as is often the case in a new field of study (Cooper, Uller, Pettifer, & Stolc, 2009; Lillard, Drell, Richey, Boguszewski, & Smith, 2015; Lillard & Peterson, 2011). The current study was designed to further explore this burgeoning area of research examining the effect of pace on attention and executive function in children and to address some of the existing flaws. This introduction will review the concept of ADHD, discuss models of ADHD and how they relate to attention and executive function, provide evidence for the effects of television on the symptoms of ADHD, and present an outline of the current study – the first to examine the effects of video pacing on attention and executive function in children with and without ADHD in a carefully controlled fashion.

Overview of ADHD

Attention-Deficit/Hyperactivity Disorder (ADHD) is the most common childhood neurobehavioral disorder (American Academy of Pediatrics, 2011). The disorder, defined by difficulties with sustained attention, problem solving, and hyperactivity is thought to affect approximately 5-10% of children and 4% of adults (Banerjee, Middleton, & Faraone, 2007). Thus, in a 20-child class room there is, on average, one child with ADHD (McGoey, Eckert, & DuPaul, 2002). ADHD has a strong genetic component, with twin studies suggesting a heritability rate as high as 70-80% (Barkley, 2014). The disorder is also known to occur in every country that has been examined worldwide, and differences in prevalence rates across cultures are thought to be due to diagnostic practices rather than actual clinical differences (American Psychiatric Association, 2013).

In addition to being one of the most prevalent childhood mental health issues, ADHD is also a highly problematic disorder across a variety of settings. Children with ADHD academically underachieve at school, have more problematic relationships with their parents, exhibit significant problems with peer functioning, and cost more to raise than children who do not have ADHD (Barry, Lyman, & Klinger, 2002; Hoza, 2007; Johnston & Mash, 2001; Swensen, Birnbaum, Secnik, Marynchenko, Greenberg, & Claxton, 2003).

Given that ADHD is a highly heritable disorder observed in every society in which it has been measured, it is unsurprising that over time various definitions and iterations of ADHD have been documented in a variety of medical and psychological journals and textbooks (Barkley & Peters, 2012). ADHD, according to the most current *Diagnostic and Statistical Manual*, DSM-5, is diagnosed in one of three forms: ADHD, Predominantly Inattentive Presentation (ADHD-I); ADHD, Predominantly Hyperactive/Impulsive Presentation (ADHD-HI); and ADHD, Combined Presentation (ADHD-C) (American Psychiatric Association, 2013).

ADHD-I (what is often colloquially, though incorrectly, referred to as "ADD") is diagnosed when 6 of 9 of the symptoms listed under Inattention are present (Table 1) without 6 of 9 of the symptoms of Hyperactivity/Impulsivity. Conversely, a diagnosis of ADHD-HI is given when 6 of 9 of the symptoms listed under Hyperactivity/Impulsivity are present (Table 1) without concomitant inattention. The diagnosis of ADHD-C is given when 6 of 9 symptoms are met for *both* the ADHD-I and ADHD-HI subtypes. The ADHD-C subtype is the most common in children, but it is unknown whether this is also true for adults (American Psychiatric Association, 2000). The following criteria must also be present for all three subtypes: symptoms must be present for at least 6 months (and inconsistent with developmental level); some symptoms which cause impairment must have been present before age 12; there must be impairment in at least two settings; the symptoms interfere with academic, social, or occupational functioning; and the symptoms cannot be better accounted for by a different mental disorder (e.g., Anxiety Disorder, or Mood Disorder). Furthermore, the symptom counts are relaxed to 5 out of 9 symptoms for adolescents over the age of 17 and adults.

Whereas this definition of the disorder is relatively new, existing in its current form since the publication of DSM-5 in 2013, the historical descriptions of symptoms of hyperactivity, impulsivity, and inattention have actually been relatively consistent for over 200 years (Lange, Reichl, Lange, Tucha, & Tucha, 2010). While the name of the disorder, the underlying concepts, and the diagnostic criteria have all changed over time, the concept that there are people, especially children, who suffer from problems in these areas has remained consistent. It is clear, then, that this is a disorder which deserves not only rich study, but also effective treatment.

For several decades, the two evidence-based treatments for childhood ADHD have been medication and psychosocial treatment (specifically behavioral training), or the combination of the two (MTA Cooperative Group, 1999). The discovery of stimulant treatment, the most widely researched class of medication for ADHD, occurred by accident when Charles Bradley, the medical director of a New England hospital, administered stimulants to children in an attempt to alleviate headaches (Gross, 1995). While the stimulants had little effect on headache pains, they did lead to an improvement in school performance and behaviors for some children. A decade after stimulants were discovered to have positive effects on symptoms of ADHD, methylphenidate, still one of the most popular medications used for ADHD, was synthesized. Further, in recent years, several non-stimulant medications (such as atomoxetine, clonidine, and guanfacine) have been approved by the Food and Drug Administration for ADHD treatment (Woods, Wolraich, Pierce, DiMarco, Muller, & Sachdeva, 2014). In addition to medications, there exist many different types of evidence-based behavioral treatments, which include behavioral parent training and behavioral interventions in the classroom (Pelham & Fabiano, 2008; Pelham, Wheeler, & Chronis, 1998). These types of interventions involve teaching parents and teachers multiple strategies to help manage the many behaviors associated with ADHD, such as using shaping techniques, implementing token economies, utilizing a time out procedure, and training parents to manage behavior outside the home (Anastopoulos & Barkley, 1990).

As was shown by the MTA Cooperative Group (1999), there is utility for the use of both types of treatment: medicine and behavioral. Due to the efficacy of both treatments, parents of children with ADHD often have difficulty deciding which treatment to pursue. Helpfully, the American Academy of Pediatrics (AAP) released clinical practice guidelines for the treatment of ADHD in 2011 (Wolraich, Brown, Brown, DuPaul, Earls, & Feldman). For preschoolers, the AAP recommends the use of behavior therapy as the first line of treatment, and to only pursue medication if treatment gains are not seen with behavioral interventions. As children enter elementary school, the recommendation is to prescribe either behavior interventions or medication, but preferably both in combination. Finally, for adolescents, the Academy recommends providing medications first, with the option for parents to pursue some type of behavior therapy – though still noting the combined approach may be the most effective.

Models of ADHD

It is important not only to understand the clinical definition of ADHD, but also the current conceptualizations of how the disorder operates. There are several models of ADHD, two of which will be discussed here: a deficit of the neurocognitive mechanism of attention; and a deficit in executive function. In addition, possible abnormalities in the brain and neural pathways will be discussed in the ways they may be connected to these models of ADHD. There is also another commonly proposed model of ADHD, focusing on motivation, which is beyond the scope of the current study. Whereas attention and executive functioning are often thought to be associated with the attentional symptoms of ADHD, motivation is instead associated with the hyperactive-impulsive symptoms (Nigg, 2006). Because this will be a study of media pacing and its effects on executive function and attention in ADHD, we will not examine this model further, although it should be noted that future studies of the effect of television pacing on the hyperactive-impulsive symptoms of ADHD may indeed choose to examine motivation in a way in which the current study does not.

Regarding the attentional model of ADHD, attention can broadly be understood as the ability to filter information (Nigg, 2006). However, within this general definition, there are several subtypes of attention which may play a role in ADHD: sustained, selective, orienting, and alerting. Sustained attention simply describes the ability to pay attention over time, and is thought to be associated with the frontoparietal areas (Hooks, Milich, & Lorch, 1994; Sarter, Givens, & Bruno, 2001). Selective attention, on the other hand, refers to the ability to attend to the relevant aspects of a task while ignoring irrelevant stimuli, and has been linked with several parts of the brain, including subregions of the posterior parietal cortex and prefrontal cortex (Hooks et al., 1994; Yantis, 2008). Orienting attention describes the spatial movement of attention toward the relevant location, and is thought to be strongly related to the parietal lobe (Berger & Posner, 2000). Finally, alerting attention is the vigilant form of attention, focusing on the ability to react to potential stimuli, and is connected with the right frontal lobe, the locus coeruleus, and the right parietal lobe (Berger & Posner, 2000; Petersen & Posner, 2012). Although there exist several models of attention, the bulk of research available suggests that these attentional systems are actually relatively intact for children with ADHD, aside from the alerting function of attention (Mullane, Corkum, Klein, McLaughlin, & Lawrence, 2011; Nigg, 2006). One common tool used to examine attentional abilities is a continuous performance task, of which one version is the Attentional Network Test (ANT). Importantly, the ANT is sensitive to examining the alerting network of attention and has been used in one of the few studies on the effects of television pace on attention (Cooper et al., 2009).

The executive functioning model of ADHD posits that a deficit in the control of goal-directed behavior is responsible for the symptoms expressed by the disorder (Barkley, 1997; Welsh, Pennington, & Groisser, 1991). The term "executive function" does not refer to a single action, but rather is an umbrella term encapsulating multiple components, including interference control, working memory (both verbal and spatial), planning, response suppression, and set-shifting (Nigg, 2006). Interference control (associated with the anterior cingulate) refers to the ability to filter out information that is unrelated to the task one is performing, whereas response inhibition (associated with the right inferior prefrontal cortex and the caudate) describes the ability to suppress an automatic or highly practiced response (Mullane, Corkum, Klein, & McLaughlin, 2009; Nigg, 2006). Working memory refers to the ability to temporarily store and manipulate information, and is linked with the central executive system, which coordinates the storage of both verbal working memory (in the phonological loop, associated with Broca's area and Wernicke's area) and spatial working memory (in the visuospatial sketchpad, associated with the visual and left prefrontal cortices) (Baddeley & Hitch, 1994; D'Esposito, Detre, Alsop, Shin, Atlas, & Grossman, 1995; Nigg, 2006). Planning describes, somewhat intuitively, the ability to strategically plan or look ahead, and has also been associated with the prefrontal cortex (Goel & Grafman, 1995). Finally, set-shifting, which is associated with the dorsolateral and medial prefrontal cortices, describes the ability to shift attention between tasks, and is commonly assessed with measures that ask participants to shift the rules they are supposed to follow between tasks (Moll, Oliveira-Souza, Moll, Bramati, & Andreiuolo, 2002; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005). In a recent thorough review of the literature, Willcutt and colleagues (2005) had a goal of identifying which components of executive functioning likely play a role in the deficits associated with ADHD. Intriguingly, evidence was found for *all* components, suggesting that executive function likely plays a role in ADHD, but is incredibly broad in its scope and function.

Therefore, seeing as the attentional, executive function, motivation, and brain/neural pathway models are all associated with the symptoms of ADHD, and that these models are broad and tend to overlap with each other (such as how the attentional and executive function models both focus on the ability to select and sustain attention, while potentially blocking out other stimuli), it is clear that no *single* model accounts for all cases of ADHD. Instead, evidence suggests that each model is an individual component of a complex neuropsychological disorder (Willcutt et al., 2005).

Television and ADHD-Related Behaviors

Television exposure may or may not be an environmental factor that exacerbates symptoms of ADHD. Given that, on average, children watch 4.5 hours of television per day (Rideout, Foehr, & Roberts, 2010), it is clear that this is an important area for further research. There are several theories as to how television may impact attention, including the effects of violent content, overall amount of television exposure, and the pace of the programming. Although doubts have been raised previously (Foster & Watkins, 2010; Stevens, Barnard-Brak, & To, 2009; Stevens & Mulsow, 2006), a recent meta-analysis examining the influence of media on ADHD-related behaviors (which addresses the studies listed above and other publications that had non-significant findings) found that whereas overall consumption of media and the amount of violent content are both correlated with ADHD behaviors, there is not yet enough research on the effects of pace of programming to examine this variable in a meta-analytic fashion (Nikkelen et al., 2014). As the current study will not utilize violent content, its potential influence will not be further examined here.

The bulk of research on media and ADHD behaviors involves examining the overall amount of media consumed. Across all stages of child development, it appears that television exposure is associated with attention problems (Kostyrka-Allchorne et al., 2017; Nikkelen et al., 2014). Longitudinal work has shown that increased television exposure as an infant is associated with increased attentional problems in middle childhood (Christakis et al., 2004). During middle childhood, exposure to television is associated with attentional difficulties, even when statistically controlling for baseline attention problems (Swing, Gentile, Anderson, & Walsh, 2010). One of the few longitudinal studies to suggest *no* meaningful connection between television exposure and ADHD suffers from the flaw that the ADHD-symptom variables used were data of convenience and "do not include an acceptable measure of ADHD" (Stevens & Mulsow, 2006, p. 665). Experimental work also suggests that *restricted* television exposure is associated with enhanced cognitive performance (Gadberry, 1980). Hence, there appear to be clear associations between the amount of television consumed by children and attentional/performance abilities.

However, it is possible that it is not simply the *amount* of television consumed which is important to consider, but also the content of the programming (Kostyrka-Allchorne et al., 2017; Nikkelen, Vossen, & Valkenburg, 2015). As previously mentioned, existing research has examined the possible link between violent content and ADHD-related behaviors (Nikkelen et al., 2014; Zimmerman & Christakis, 2007). A much less studied, but possibly important, area of research involves examining the *pacing* (edits, cuts, scenery changes, etc.) of the programs children are watching. The few studies which have examined pace have hypothesized that faster pace would be associated with decreased attentional and executive functioning abilities (Cooper et al., 2009; Lillard & Peterson, 2011). This hypothesis seems reasonable, as it is possible that if a child with ADHD is struggling with the alerting aspect of attention while watching television (i.e., having difficulty responding to stimuli without warning), she or he may have more difficulty responding to the cuts and edits seen on television. Although cuts and edits are a common part of television and movies, they may not seem intuitively "natural" in the sense that they may happen at seemingly random points of the video, which the child may not be expecting. In addition, it is conceivable that if a child has a deficit in working memory, he or she may not be able to easily store the information contained in the separate camera angles presented in a single scene of a show; therefore, the child could have more difficulty understanding and integrating the content as these different angles are cross-cut against each other at a fast pace. Further, a child who struggles with shifting may find it more difficult to follow the many edits contained in a fast-paced program as opposed to the long takes contained in slower-paced programming.

Possible Mechanisms & Theories. Given that this area of research is still in its infancy, there is not yet a clear consensus as to why the pace of television is linked to attention and executive functioning. However, several theories have been put forth, suggesting either long term or short term effects. Regarding the long term hypotheses, in a study examining the association between early television exposure (1-3 years old) and later attentional problems, Christakis and colleagues (2004) note that exposure to fast-paced television may result in overstimulation and hinder the development of neural synapses. Further, it has been theorized that time spent watching television may take the place of other activities which support attention, such as playing outside or reading, and that *fast*-paced television may encourage an attentional style of quickly scanning and shifting, making it more difficult to later engage in sustained attention tasks (Jensen, Mrazek, Knapp, Steinberg, Pfeffer, Schowalter, & Shapiro, 1997; Landhuis et al., 2007; Nikkelen et al., 2014).

Regarding the short term hypotheses, it is possible that the fast pace of television may simply make the real world seem boring by contrast (Landhuis et al., 2007) or that it may increase immediate arousal, but result in underarousal in less stimulating situations (Lang, Zhou, Schwartz, Bolls, & Potter, 2000). It has also been suggested that fast-paced media require more executive resources to encode events, thus depleting resources that could otherwise be available for future tasks or activities (Lillard & Peterson, 2011). However, there is clearly a fair amount of overlap among these theories, and it is possible that multiple pathways account for both short *and* long term effects of exposure to fast-paced media. For example, if a child is engaging in a task requiring sustained attention (such as completing homework) immediately after watching a fast-paced cartoon, he or she may be "primed" to scan and shift quickly. At the same time, the child may *also* experience underarousal while engaging in this later, less stimulating task.

History of Empirical Research on Pace and Attention & Executive Functioning. The earliest study examining the effects of pacing on attention and executive functioning processes (Anderson, Levin, & Lorch, 1977) consisted of three experimental groups: children shown 40 minutes of fast-paced *Sesame Street* clips; children shown 40 minutes of slow-paced *Sesame Street* clips; and a control group that had stories read to them by their parents. On measures of cognitive impulsivity, perseverance, and directed play, there were no significant differences found between the groups. Although this initial study seems not to support the hypothesis that fast-paced programs have a negative impact on attentional abilities, later work has noted that modern audiences consume media which is much faster than even the "fast-pace" edit of *Sesame Street* (Koolstra, van Zanten, Lucassen, & Ishaak, 2004; Lillard & Peterson, 2011). As such, some work using more modern programs supports the idea that pace negatively influences attention. Geist and Gibson (2000) assigned children to one of three treatment groups: watch an episode of *Mister Rogers' Neighborhood* (a slow-paced show), watch an episode of *The Mighty Morphin' Power Rangers* (a fast-paced show), or play with child development activities (e.g., finger painting, play dough, Legos, etc.). Immediately after participating in their assigned activity, all the children played with the child development activities in one large group, and their ability to attend to tasks was measured. Whereas there were no significant differences between the slow-paced group and the control group, the fast-paced group spent less time on tasks and changed tasks more often than did the control group. Similarly, Lillard and Peterson (2011) presented children with truncated episodes of either a fast-paced television show starring a sponge who lives in the ocean (*SpongeBob SquarePants)*, or a truncated episode of a realistic and slow-paced show about a pre-schooler living in the United States (*Caillou)*; a control group was allowed to draw freely with markers and crayons. Across several measures of executive function, the children watching the fast-paced show performed more poorly than the children in either the control or slow-paced group. However, the authors noted that in addition to pace, the amount of fantastical content obviously differed between the two shows and was therefore another plausible explanation for the effects. In a follow-up study, Lillard and colleagues (Lillard, et al., 2015) replicated the original work with a different episode of *SpongeBob SquarePants*, and an additional fast-paced fantastical show, *Fanboy and Chum Chum*. Again, they compared the fast-paced shows to a slow-paced realistic cartoon (*Arthur*) and a free play group; results again showed that children performed more poorly on most measures of executive functioning after watching fast-paced programming in comparison to children who watched a slower cartoon or engaged in free play. In a secondary project as part of the same 2015 study, they also found that children performed similarly on measures of executive functioning after a fast-paced educational show (*Martha Speaks*) and a fast-paced fantastical show (*SpongeBob SquarePants*).

However, another study found significant effects regarding the pace of television on attentional abilities, but not consistently in the expected direction (Cooper et al., 2009). Children were shown a video of a narrator reading a book edited either at a fast pace (a change in camera angle every 4 seconds) or slow pace (a change in camera angle every 15 seconds). The findings involved an interaction between video pace and the age of the child, such that 4-year-olds performed better on an attentional network test in the fast-paced group, whereas the opposite was found for children who were 6 or 7 years old. In addition, the children in the slow-paced group made more errors on the test than did those in fast-paced group. Further, in another study by Lillard et al. (2015) examining the influence of both pace *and* fantastical elements on executive functioning, there was an effect for fantasy content (such that children who watched highly fantastic shows performed worse) but not for pace. Nevertheless, one of the few other experimental studies examining the pace of television programs found slow-paced programs were recalled more accurately by children than were fast-paced programs (Wright et al., 1984). Given the discrepant findings in this very limited research base, there has been a call for more studies that directly manipulate the pace of programming consumed by children (Nikkelen et al., 2014).

Current Study

Although there are a handful of studies examining the possible association between television pace and symptoms associated with ADHD, most of the existing literature suffers from important flaws. For example, the first study to examine this line of research (Anderson et al., 1977) compared fast and slow edits of *Sesame Street*, but did so by combining many individual clips from separate episodes, as opposed to presenting the children with a linear, unedited episode. Thus, the content the children watched was not only completely different between the two conditions in the study (rapid-paced and slow-paced), but was also unlike what they consume in the real world, decreasing the external validity of the results.

The more recent study by Cooper and colleagues (2009), which found an interaction between speed of editing and age, also suffered from flaws in the creation of the content the children watched. Although the content was similar between pacing conditions in terms of plot, the children were only presented with a recording of a man reading a book to the camera, which is likely different from what they regularly see on television. The authors note that this allowed them to present fast-paced and a slow-paced versions of the same content; however, they did so in a medium which is foreign for many children. In addition, only a single outcome measure was used, the Attention Network Task (ANT). Cooper and colleagues report that their finding of an interaction of age and speed of editing may be due to a flaw with the ANT itself (that high orienting scores may suggest *efficient* use of the spatial cue as opposed to being associated with *difficulty* disengaging with the cue [Fan & Posner, 2004]), and suggest that their results should therefore be interpreted with caution.

Further, even the most recent studies (Lillard et al., 2015; Lillard & Peterson, 2011), which mostly support the hypothesis that faster-paced programs will negatively impact executive functioning skills, contain a major flaw. Although these studies used real-world television programs (albeit sometimes edited into truncated versions), the authors consistently compare *different* shows. Therefore, while pace may certainly be a contributing factor to the findings, it is difficult to say it is the *only* explanation. In addition to different pace, the shows contained different characters, different plots (both realistic, fantastical, and programs such as *Sesame Street* which straddle the divide), different voices, different sounds, different images, and so on. Although Lillard et al. (2015) note that fantastical elements may be driving more of the effect than pace, they are still comparing completely different television shows, which means there are clearly many more differences than just pace and elements of fantasy at play. For this reason, it is very difficult to conclude that pace (or fantasy) fully accounts for the findings.

Finally, whereas several previous studies have examined the associations between pace and symptoms of ADHD, they have all used “Typically Developing” children in their studies. The current study is the first to specifically recruit children who meet criteria for a *diagnosis* of ADHD. By including children with ADHD, in addition to Typically Developing children, this project is able to examine the influence of television pace in a subset of children who may be most at risk for any possible negative effects on the symptoms of ADHD.

Overall Significance. The research reviewed thus far highlights the need for continued (and improved) work examining the effect of pace on children’s attentional abilities and executive functioning. If there is indeed a link between pace and attention or executive function, as suggested by Cooper et al. (2009), this has important implications for parents, health care providers, and even the creators of the television programming. Parents are often told that their children should or should not watch certain types or amounts of television (American Academy of Pediatrics, Committee on Public Education, 1999), but it is often difficult to understand why certain media should be avoided and which should be recommended. In addition, if a connection between the pace of programming and attention or executive function is found, parents will be able to better plan when children participate in activities that *require* attention (such as completing homework), health care providers will be able to give specific advice regarding which shows to avoid or pursue, and the media industry may even be able to create content which is optimal for children. Further, potential findings could have an even more important impact for families of children with ADHD (and the teachers and healthcare providers who work with them). As the alerting model of Attention and all aspects of Executive Functioning are thought to be impacted by ADHD, children with this disorder are already operating at a deficit in these areas. Thus, after watching a fast-paced program, a child with ADHD, who likely “fails to give close attention to details or makes careless mistakes in schoolwork” and “has difficulty sustaining attention” (American Psychiatric Association, 2013), may struggle even more than the hypothetical child described in the homework example above.

Present Study: Aims & Hypotheses

Based on the minimal amount of research examining the role of pace of television on symptoms of ADHD, and the problems contained in the few existing studies, the current study focuses on manipulating the pace of a single animated video designed for school-aged children (with and without ADHD), while controlling for characteristics that differ across group. By using an animated video with the same content (aside from the pace at which it is edited), we strove to isolate pace as the only variable which differed between the two groups. In doing so, we hoped to improve upon previous studies which have used different clips for their experimental conditions (Anderson et al., 1977; Lillard & Peterson, 2011). In addition, by using an animated video (as opposed to something similar to the live recording utilized by Cooper et al., [2009]), we were able to examine media which is more similar to that which is normally watched by children (Gunter & McAleer, 1997).

Specific Aim 1: To determine if a diagnosis of ADHD influences performance on measures of attention and executive functioning.

Hypothesis 1: Typically developing children will perform better than children with ADHD on baseline measures of attention and executive functioning (Trail Making Test and an antisaccade task).

Specific Aim 2: To determine if the pace of a video influences performance on measures of attention and executive functioning.

Hypothesis 2: Relative to the fast-paced video, children will perform better on measures of attention and executive functioning (Stop Signal Task and Attentional Network Test) after watching the slower-paced video.

Specific Aim 3: To determine the influence of ADHD-status on attention and executive functioning outcomes after watching slow and fast-paced videos.

Hypothesis 3: Children with ADHD will perform more poorly in comparison to Typically Developing children on measures of attention and executive functioning after viewing either slow or fast-paced videos. However, an interaction of group (Typically Developing children vs. children with ADHD) by pace (slow vs. fast) is expected: the performance of children with ADHD will be worse than that of Typically Developing children in the fast, relative to the slow, paced video. The proposed interaction is described in Figure 1.

Methods

Participants

A total of 41 children (34% female; 90% white) ages 6 to 14 years, and one of their primary caregivers, participated in the current study; 24 children were in the Typically Developing group and 17 were in the ADHD group. One member of the ADHD group was lost to follow up after the initial visit. Participants were recruited locally using a variety of methods; recruitment procedures are further described below. To be eligible as a member of the ADHD sample, children must have had elevated symptoms on the ADHD Rating Scale - IV (DuPaul, Power, Anastopoulos, & Reid, 1998), defined as either: 1) a positive endorsement of at least 6 symptoms of either inattention or hyperactivity-impulsivity, or both, or 2) achieving scores in the 90^{th} percentile or above on the age and gender-normed Total, Inattention, or Hyperactivity-Impulsivity scales. Children were eligible as Typically Developing participants if they did *not* have elevated symptoms on the ADHD Rating Scale - IV (DuPaul et al., 1998), defined as both: 1) achieving 5 or fewer symptom endorsements of inattention and hyperactivity-impulsivity, and 2) achieving scores below the 90^{th} percentile on the Total, Inattention, and Hyperactivity-Impulsivity scales of the ADHD Rating Scale - IV. In order to be eligible, all child participants (ADHD and Typically Developing) were also required to score below clinical threshold on brief screeners for depression (Patient Health Questionnaire-2, PHQ-2) and anxiety disorders (Screen for Child Anxiety Related Emotional Disorders, SCARED), and must have resided with their primary caregiver for at least 6 months. Demographic information for all child participants can be seen in Table 2 and the reasons potential participants were deemed ineligible can be seen in Table 3.

Procedure

Children and caregivers were recruited from the Vermont Center for Children, Youth and Families (VCCYF), Vermont Psychological Services, and from the general population using flyers and advertisements in newspapers, online (Front Porch Forum, Facebook, Children and Adults with Attention-Deficit/Hyperactivity Disorder), and in the community (pediatrician's offices, storefront windows, community bulletin boards) targeting parents of children with and without ADHD who may be interested in participating in media research. Interested families participated in an initial phone or online screen to determine if they met eligibility criteria for participation in the study (listed above). Those who met eligibility requirements of the initial screen were invited to visit the research facility to participate in the two-session project. A trained Research Assistant obtained consent from the participating caregiver and consent/assent from the child at the beginning of the first visit. Subsequently, parents completed reports about their children's behaviors and psychological adjustment, and the children participated in two baseline measurements (Trail Making Test and antisaccade task) and a brief cognitive assessment (Wechsler Abbreviated Scale of Intelligence, Second Edition). During the second visit, the children watched two versions of a cartoon (fast-paced and slow-paced) and completed an attention or executive functioning task (Stop Signal Task or Attentional Network Test) after each viewing. All children watched the fast and slow edits of the cartoon, with half of the sample in the ADHD group and half the sample in the control group watching the fast-paced edit first, and the other half watching the slow-paced edit first, with the post-measures also counterbalanced. Participants were compensated with $50 ($25 at visit 1 and $25 at visit 2). All procedures were approved by the University of Vermont (UVM) Institutional Review Board (IRB).

Cartoon Video

All children watched two versions of a 9 minute and 30 seconds long cartoon. Both versions of the cartoon contained the exact same content, but were edited at a fast pace (190 cuts/edits; approximately 20 per minute) and a slow pace (67 cuts/edits; approximately 7 per minute). The design of the cartoon resembled *South Park* or *Caillou* (Figures 2a and 2b), in that it featured young animated characters in an everyday (i.e., non-fantastical) setting. Both versions contained the same story, characters, dialogue, sound effects, music, and visual images; the only difference was the length of the individual shots.

Measures Completed by the Parent

Assessment of Current Media Use. Parents completed a questionnaire that assesses how much media their children use on both weekdays and weekends. Parents first list the different kinds of media devices they have in the home (e.g., Cable or satellite TV, smartphone, tablet computer, laptop or desktop computer, handheld video game console). Next, parents are asked how much time their children spend on a variety of activities separately on weekdays and weekends (e.g., watching TV or DVDs, reading print media, playing video games on a console, using a smartphone for reasons other than talking on the phone).

ADHD Rating Scale. ADHD symptoms were measured with the ADHD Rating Scale – IV (DuPaul et al., 1998). This well-normed measure is used as a screening tool to identify participants with elevated ADHD symptoms. Symptom frequencies are indicated on 18-items utilizing a 4-point Likert scale (0 = Never or rarely, 3 = Very often), with parents asked to describe behavior over the last 6 months. There are two subscales, each based on DSM-IV criteria (consistent with DSM-5 criteria), with nine questions comprising the Inattention subscale (sample item: “Is easily distracted”) and nine comprising the Hyperactivity-Impulsivity subscale (sample item: “Has difficulty awaiting turn”). The raw scores for items of each subscale are summed (with higher scores reflecting greater symptom severity). The summation of these subscales produces the Total Scale score. Norms are available by gender and age.

The ADHD Rating Scale – IV has exhibited good internal consistency reliability (total score alpha = .92; Inattention alpha = .86; and Hyperactivity-Impulsivity alpha = .86) in a sample of 71 children ages 5-17 years-old (DuPaul et al., 1998). Criterion-referenced validity has been measured by comparing the ADHD Rating Scale – IV to the Conners Teacher Rating Scale-39 (Conners, 1989), Conners Parent Rating Scale-48 (Conners, 1989), behavior observations for fidgety and off-task behavior that were adapted from the ADHD Behavior Code (Barkley, 1990), and an academic efficacy score (Rapport, DuPaul, & Kelly, 1989). Overall, the correlation coefficient absolute values, all in the expected direction, ranged from .10 to .81 (DuPaul et al., 1998). Discriminant validity was demonstrated in a sample of 92 children being assessed for ADHD (DuPaul et al., 1998).

Child Behavior Checklist (CBCL). The CBCL is a 113-item instrument that assesses behavioral and emotional functioning, and collects demographic data (race, ethnic group, age, gender, and parental occupation) via parent report (Achenbach & Rescorla, 2001). The items are rated on a 3-point scale that indicates how true each item is for the child within the past six months (0 = Not True, 1 = Somewhat or Sometimes True, 2 = Very True or Often True; sample item: "Cries a lot"). The measure generates eight empirically based syndrome scales (Anxious/Depressed, Withdrawn/Depressed, Somatic Complaints, Social Problems, Thought Problems, Attention Problems, Rule Breaking Behavior, Aggressive Behavior), six DSM-oriented scales (Depressive Problems, Anxiety Problems, Somatic Problems, Attention Deficit/Hyperactivity Problems, Oppositional Defiant Problems, Conduct Problems), and overall Internalizing Problems, Externalizing Problems, and Total Problems scales. Test-retest reliability over an eight day period has been reported as r = .88 for the overall measure, with a range between .80 (Anxiety Problems) and .93 (Attention Deficit/Hyperactivity Problems). Internal consistency has also been demonstrated, with Cronbach's alpha ranging from .72 (Anxiety Problems) to .94 (Aggressive Behavior) (Achenbach & Rescorla, 2001). The Hollingshead index (Hollingshead, 1975), a nine-step rating scale of parental occupation, was used to calculate socioeconomic status (SES) based off CBCL occupation data; the highest of two scores was used when more than one care-giver was employed.

Patient Health Questionnaire-2 (PHQ-2). Depressive symptoms were assessed with the 2-item parent report of the PHQ (Kroenke, Spitzer, & Williams, 2003). This brief screening measure was used to identify participants who may be experiencing a current major depressive episode, and would therefore be ineligible. Parents were asked if their child has been experiencing either of the following items over the past two weeks: 1) little interest or pleasure in doing things or 2) feeling down, depressed, or hopeless. Parents are asked to respond on a 4-point Likert scale: 0 = Not at all, 1 = Several days, 2 = More than half the days, 3 = Nearly every day. For the current study, a child was considered eligible if the parent answered 0 or 1 on both items. The measure has demonstrated construct and criterion validity in general adult populations (Kroenke et al., 2003), shows good specificity and sensitivity in detecting major depression in teenage adolescents (Richardson, Rockhill, Russo, Grossman, Richards, McCarty,... & Katon, 2010) and has been used as a parent screener of child depression symptomatology in previous work (Vreeman, Scanlon, Mwangi, Turissini, Ayaya, Tenge, & Nyandiko, 2014).

Screen for Child Anxiety Related Emotional Disorders (SCARED). Anxiety symptoms were assessed with the 41-item parent report version of the SCARED (Birmaher, Brent, Chiappetta, Bridge, Monga, & Baugher, 1999). This screening measure was used to identify potential ineligible participants (i.e., those who have elevated levels of anxiety). Symptoms are assessed using a 3-point Likert scale (0 = Not True or Hardly Ever True, 1 = Somewhat True or Sometimes True, 2 = Very True or Often True; sample item: "My child worries about what is going to happen in the future"), with parents asked to choose the response that best describes the child over the past 3 months. The measure produces a total Anxiety Disorders scale, and five subscales: Panic Disorder/Significant Somatic Symptoms, Generalized Anxiety Disorder, Separation Anxiety Disorder, Social Anxiety Disorder, and Significant School Avoidance. The total Anxiety Disorders scale was used for the current study; potential participants who scored below a 30 (threshold for a possible specific anxiety disorder) were deemed eligible. The SCARED has demonstrated good psychometric properties, including satisfactory internal consistency, discriminant validity, and test-retest reliability (Birmaher et al., 1999).

Measures Completed by the Child

Trail Making Test. The Trail Making Test is a neuropsychological test used to assess attention and executive functioning abilities. The test consists of two parts and was originally a component of the Army Individual Test Battery (1944), and is now a part of the Halstead-Reitan Battery (Reitan & Wolfson, 1985). In the first part of the task, "Trails A," the child connects 25 encircled numbers, in ascending order, that are scattered on the page. In the second part of the task, "Trails B," the child connects 25 items, this time alternating between numbers and letters (e.g. 1, A, 2, B, 3, C, etc.). The raw score for each part is the amount of time needed to complete the task, which is then converted to an age-adjusted *T*-score based on normative data. Trails A is considered to be a measure of attention/processing speed, whereas Trails B is considered a measure of executive functioning (Dwan, Ownsworth, Chambers, Walker, & Shum, 2015). In addition, the difference in raw time between Trails B and Trails A is considered to be an index of set-shifting ability. Test-retest reliability has been demonstrated for the task in several samples (Matarazzo, Matarazzo, Wiens, Gallo, & Klonoff, 1976).

Antisaccade Task. The antisaccade task is a computer-based measure developed to assess three areas of executive functioning: response suppression, inhibitory control, and task switching. In an antisaccade task, participants are asked to look at a target at the center of a monitor, while a stimulus flashes on either side of the target, with the participant asked to look not at the stimulus, but in the opposite direction – thus performing an antisaccadic eye movement (Bialystok, Craik, & Ryan, 2006). If the participant instead fails to avoid responding to the stimulus and looks in that direction, he has engaged in a prosaccadic eye movement. The task in the current study is similar to one used in previous work (Herdman & Ryan, 2007). A shortened version of the measure was utilized in the current project to encourage compliance in the study population (i.e., young and who may meet criteria for ADHD); this change cuts the administration time approximately in half (15-20 minutes, as opposed to 40 minutes) and still allows for measurement of two of the three areas of executive functioning (response suppression and task switching). Children are first shown a neutral stimulus (a cartoon face; see Figure 3) in the center of a computer screen, with boxes on either side of the face, for 1000 msec. Next, the children are shown the same face with either red or green eyes for 500 msec. If the eyes are green, they are asked to make a prosaccadic movement (toward the target), and if they are red they are asked to make an antisaccadic movement (away from the target). The face is then removed, leaving just the two boxes for 200 msec, after which an asterisk is shown in one of the boxes for 200 msec. When the eyes are green, the children are to look at the box with the asterisk, and when they are red, they are to look at the other box. Participants will complete 4 blocks of 64 trials each. Incorrect responses and reaction times shorter than 80 ms and longer than 2,000 ms on the antisaccade task are omitted from analyses (Bialystok et al., 2006). The response suppression score is the mean difference between a block of only antisaccades (red eye condition) and a block of only prosaccades (green eye condition) when the eyes are facing straight ahead (as measured by a camera tracking all eye movements). Task switching is measured as the difference in mean response time between corresponding tasks in each of the blocked presentations (in which only one color of eyes is shown) and the mixed presentations (in which a mix of green and red eyes is shown) when the eyes are facing ahead.

Wechsler Abbreviated Scale of Intelligence, Second Edition (WASI-II). The WASI-II (Wechsler, 2011), is a measure of cognitive intelligence designed for ages 6 to 90. The measure consists of four subtests: Block Design (an evaluation of nonverbal concept formation, fluid intelligence, visual perception and organization, and visual motor coordination), Vocabulary (an evaluation of word knowledge, verbal concept formation, fund of knowledge, degree of language development, and crystallized intelligence), Matrix Reasoning (an evaluation of spatial ability, fluid and visual intelligence, and perceptual organization), and Similarities (an examination of crystallized intelligence, verbal concept formation, abstract reasoning, associative and categorical thinking, and verbal expression). Scoring guidelines are provided in the manual. Raw scores for each subtest are converted to T-scores, which convert to either a Full Scale IQ-4 standard score (when all subtests are administered) or a Full Scale IQ-2 (when only Vocabulary and Matrix Reasoning are administered). The Full Scale IQ-2 was used in the current study.

Stop Signal Task. The Stop Signal Task is a computer-based assessment of response inhibition (Logan, Schachar, & Tannock, 1997). It consists of two tasks that are presented concurrently: a go task and a stop task. During the go task, children are presented with an *X* or an *O*, with an equal chance of either appearing, and are asked to press a corresponding key as quickly as possible, without making an error. The stop task, which occurs 25% of the time, presents the child with a tone, indicating he or she is to inhibit the response to the task (i.e., not to press the key). The timing of the tone is varied, in order to estimate the speed of the child's inhibition process (Nigg, 2006). The tone is first presented 250 ms after the presentation of the letter. If the participant correctly inhibits, the delay is increased 50 ms, making the task more difficult; if the participant does not inhibit, the delay is decreased 50 ms, in order to make the task easier. A Stop Signal Reaction Time (SSRT) is calculated which reflects the time it takes to inhibit a response.

Attentional Network Test. The child version of the Attentional Network Test (ANT) is a computer-based continuous performance task developed to assess three attentional networks: alerting, orienting, and executive control (Rueda et al., 2004). The task asks children to feed a fish (i.e., respond to the direction the fish is facing by pressing the right or left arrow) that is either by itself or centrally located in a row of five fish. The task consists of neutral trials, in which the fish is presented alone; congruent trials, in which all five fish face in the same direction; and incongruent trials, in which the four flanking fish face in the opposite direction of the target fish. There are a total of 168 trials, one 24-trial practice block, followed by three blocks of 48 trials. Before the presentation of each trial, one of four cues is presented for 150 ms: a center cue (where the target fish will be), a double cue (both above and below the target fish), a spatial cue (either above or below the target fish), or no cue. After a 450 ms fixation period, the stimulus is presented until a response is detected, up to a maximum of 1,700 ms. Incorrect responses (e.g., the child presses the left arrow when the fish is facing right) are excluded from attentional network calculations. The alerting network is measured by the difference in times between the no cue trials and the double cue trials, the difference between the incongruent and congruent trials measures the executive control network, and the difference between the center cue trials and the spatial cue trials measures the orienting network.

Data Analytic Plan

Aims and hypotheses are restated below for clarity, followed by the data analytic approach for each hypothesis.

Specific Aim 1: To determine if a diagnosis of ADHD influences performance on measures of attention and executive functioning.

Hypothesis 1: Typically Developing children will perform better than children with ADHD on baseline measures of attention and executive functioning (Trail Making Test and an antisaccade task).

Specific Aim 2: To determine if the pace of a video influences performance on measures of attention and executive functioning.

Hypothesis 2: Relative to the fast-paced video, children will perform better on measures of attention and executive functioning (Stop Signal Task and the ANT) after watching the slower-paced video.

Specific Aim 3: To determine the influence of ADHD-status on attention and executive functioning outcomes after watching slow and fast-paced videos.

Hypothesis 3: Children with ADHD will perform more poorly in comparison to Typically Developing children on measures of attention and executive functioning after viewing either slow or fast-paced videos. However, an interaction of group (Typically Developing children vs. children with ADHD) by pace (slow vs. fast) is expected: the performance of children with ADHD will be relatively worse than that of Typically Developing children in the fast, relative to the slow, paced video.

Preliminary analyses. As a first step, independent samples *t*-tests were utilized to examine if the ADHD and Typically Developing groups differed on CBCL subscales, continuous demographic variables drawn from the CBCL (age, socioeconomic status), Full Scale IQ score, or current media use. Demographic variables that were categorical (race/ethnicity, gender) were examined using chi-square statistics. Variables that were significantly different between the groups were used as covariates in further analyses.

Primary analyses. For Specific Aim 1, ANCOVAs were conducted with scores on the Trail Making Test and the antisaccade task as the dependent variables with ADHD status as the independent variable. For Specific Aims 2 and 3, two (group; children with ADHD vs. Typically Developing children) x two (pace; fast vs. slow) separate ANCOVAs were conducted with each outcome measure (Attentional Networks [Alerting, Orienting, and Executive Control] and Stop Signal Reaction Time) as the dependent variable, group (ADHD and Typically Developing) and pace (fast and slow) as the independent variables, and appropriate covariates. Hypothesis 2 was tested by examining the main effect of pace and Hypothesis 3 was tested by examining the main effect of group; the proposed interaction was explored via planned comparisons of estimated marginal means. For all analyses, pairwise deletion was used for missing data. Results for primary analyses are discussed in terms of Effect Sizes (partial eta squared; $p\eta^2$) because of the small sample size of this pilot study, and corresponding low statistical power, which may allow for significant results to go undetected. Partial eta squared allows for use of Cohen’s (1969) effect size norms (small = .0099, medium = .0588, large = .1379). Because this measure of effect size can generalize to all designs (including those with covariates), inclusion in the current pilot study may prove to be important for future researchers (Richardson, 2011). Notably, the two most recent studies (Lillard et al., 2015;

Lillard & Peterson, 2011) provide $p\eta^2$, which allowed for comparison between their findings and those in the current study.

Results

Descriptive Statistics and Correlations

Descriptive statistics for study variables are presented in Tables 4 (Visit 1) and 5 (Visit 2). Correlations between study variables are presented in Table 6. Prior to running the correlations, outcome variables (CBCL, Trail Making Test, antisaccade task, Stop Signal, and the ANT) were standardized by converting raw scores into *z*-scores; Full Scale IQ was not converted to a *z*-score as it is already standardized. Standardized scores were used for all following analyses.

Preliminary Analyses

Independent samples *t*-tests and chi-square statistics were utilized to examine if the ADHD and Typically Developing groups differed on demographic variables drawn from the CBCL (race, ethnic group, age, gender, and socioeconomic status), Full Scale IQ score, or current media use. Full Scale IQ was the only variable significantly different ($p < .01$) between the groups and was therefore included as a covariate in the primary analyses. Independent samples *t*-tests were also run between the ADHD and Typically Developing groups for the CBCL scales. Results indicated significant differences for several scales such that the ADHD group was rated as experiencing higher levels of problems than the Typically Developing group: Anxious/Depressed, $p < .05$; Social Problems, $p < .01$; Thought Problems, $p < .01$; Attention Problems, $p < .01$; Rule Breaking Behavior, $p < .05$; Aggressive Behavior, $p < .01$; Depressive Problems, $p < .01$; Anxiety Problems, $p < .05$; Attention Deficit/Hyperactivity Problems, $p < .01$; Oppositional Defiant Problems, $p < .01$; Conduct Problems, $p < .05$; Internalizing Problems, $p < .05$; Externalizing Problems, $p < .01$; and Total Problems, $p < .01$. Given that there were significant differences across most subscales and that it makes theoretical sense that the ADHD and Typically Developing groups would differ on Externalizing subscales, the Internalizing Problems subscale was used as a covariate in further analyses to achieve the most parsimonious ANCOVAs.

Primary Analyses

Specific Aim 1: To determine if a diagnosis of ADHD influences performance on measures of attention and executive functioning.

ANCOVAs were conducted with scores on the Trail Making Test (Trails A, Trails B, and the difference between them) and the antisaccade task (Task Switching and Response Suppression) as the dependent variables, ADHD status as the independent variable, and IQ and Internalizing Problems as covariates to examine whether Typically Developing children performed better than children with ADHD on baseline measures of attention and executive functioning. Regarding Trail Making Trails A, an ANCOVA revealed a non-significant but small effect size for ADHD status ($F[1, 37] = 1.921$, $p = .174$, $p\eta^2 = .049$) and Full Scale IQ ($F[1, 37] = 1.438$, $p = .238$, $p\eta^2 = .037$), and no main effect of Internalizing Problems ($F[1, 37] = .003$, $p = .957$, $p\eta^2 = .000$). For Trailmaking Trails B, the ANCOVA revealed a large effect for Full Scale IQ ($F[1, 37] = 7.824$, $p = .008$, $p\eta^2 = .175$), and a non-significant but small effect for ADHD ($F[1, 37] = .867$, $p = .358$, $p\eta^2 = .023$) and Internalizing Problems ($F[1, 37] = .958$, $p = .334$, $p\eta^2 = .025$). The ANCOVA for the difference between Trails B and Trails A revealed a non-significant but small effect for IQ ($F[1, 37] = 1.073$, $p = .307$, $p\eta^2 = .028$) and Internalizing Problems ($F[1, 37] = .937$, $p = .339$, $p\eta^2 = .025$), and no effect for ADHD ($F[1, 37] = .138$, $p = .712$, $p\eta^2 = .004$).

Regarding the antisaccade task, the ANCOVA for Response Suppression revealed a non-significant but small effect for ADHD status ($F[1, 28] = .504$, $p = .483$, $p\eta^2 = .018$), and no main effect for Full Scale IQ (*F*[1, 28] = .118, *p* = .734, $p\eta^2$ = .004) or Internalizing Problems (*F*[1, 28] = .102, *p* = .752, $p\eta^2$ = .004). The ANCOVA for Task Switching revealed a non-significant small effect size for ADHD status (*F*[1, 28] = .883, *p* = .355, $p\eta^2$ = .031) and Full Scale IQ (*F*[1, 28] = .792, *p* = .381, $p\eta^2$ = .028), and no main effect of Internalizing Problems (*F*[1, 28] = .159, *p* = .693, $p\eta^2$ = .006).

Specific Aims 2: To determine if the pace of a video influences performance on measures of attention and executive functioning and 3: To determine the influence of ADHD-status on attention and executive functioning outcomes after watching slow and fast-paced videos.

Two (group; children with ADHD vs. Typically Developing children) x two (pace; fast vs. slow) ANCOVAs were conducted separately with each outcome measure (ANT and Stop Signal) as the dependent variable, group (ADHD and Typically Developing) and pace (fast and slow) as the independent variables, and IQ and Internalizing Problems as covariates[1]. Estimated marginal means for each ANCOVA are presented in Figures 4-7, and Table 7 presents effect sizes and significance levels for each task. The ANCOVA for the ANT Alerting Network (see Figure 4) revealed non-significant but small effect sizes for pace (*F*[(1, 28] = 1.231, *p* = .277, $p\eta^2$ = .042) and the interaction between pace and ADHD (*F*[1, 28] = .512, *p* = .480, $p\eta^2$ = .018), a non-significant medium effect size for IQ (*F*[1, 28] = 3.715, *p* = .064, $p\eta^2$ = .117), a large effect for Internalizing Problems (*F*[1, 28] = 5.203, *p* = .030, $p\eta^2$ = .157) and no main effect of ADHD (*F*[1, 28] = .117, *p* = .735, $p\eta^2$ = .004). For the ANT Orienting Network (see Figure 5), the ANCOVA revealed non-significant but small effect sizes for pace (*F*[1, 28] = .288, *p* = .596, $p\eta^2$ = .010) and IQ (*F*[1, 28] = .446, *p* = .510, $p\eta^2$ = .016), and no main effect for ADHD (*F*[1, 28] = .054, *p* = .817, $p\eta^2$ = .002), Internalizing Problems (*F*[1, 28] = .047, *p* = .831, $p\eta^2$ = .002), or the pace by group interaction (*F*[1, 28] = .024, *p* = .879, $p\eta^2$ =

.001). For the ANT Executive Control network (see Figure 6), there was a non-significant but small effect size for pace ($F[1, 28] = .415$, $p = .524$, $p\eta^2 = .015$), IQ ($F[1, 28] = 1.354$, $p = .254$, $p\eta^2 = .046$), Internalizing Problems ($F[1, 28] = 1.231$, $p = .277$, $p\eta^2 = .042$), and the pace by group interaction ($F[1, 28] = .747$, $p = .395$, $p\eta^2 = .026$), and a non-significant medium effect for ADHD ($F[1, 28] = 1.763$, $p = .195$, $p\eta^2 = .059$). Finally, the ANCOVA for Stop Signal Reaction Time (see Figure 7) revealed a non-significant but small effect size for pace ($F[1, 33] = 1.082$, $p = .306$, $p\eta^2 = .032$), IQ ($F[1, 33] = 1.710$, $p = .200$, $p\eta^2 = .049$), and Internalizing Problems ($F[1, 28] = .720$, $p = .402$, $p\eta^2 = .021$), a non-significant medium effect for ADHD ($F[1, 33] = 2.118$, $p = .155$, $p\eta^2 = .060$), and no effect for the pace by group interaction ($F[1, 33] = .257$, $p = .616$, $p\eta^2 = .008$).

The small effect of the group by pace interactions was explored via planned comparisons of estimated marginal means. For the Alerting Network, it revealed a non-significant but small effect of pace for children with ADHD ($F[1, 28] = 1.312$, $p = .262$, $p\eta^2 = .045$) but no effect for Typically Developing children ($F[1, 28] = .090$, $p = .766$, $p\eta^2 = .003$). For the Executive Control Network, there was also a non-significant but small effect of pace for children with ADHD ($F[1, 28] = .906$, $p = .349$, $p\eta^2 = .031$) but no effect for Typically Developing children ($F[1, 28] = .040$, $p = .843$, $p\eta^2 = .001$).

Discussion

For years, parents, physicians, and researchers have wondered what kind of effect television programs have on their children. Given some of the colorful synonyms for television (boob tube, idiot box, etc.), many adults assumed these possible effects would be negative. Indeed, research has shown that there can be unwelcome effects from television (Nikkelen et al., 2014) but it has done so inconsistently (Kostyrka-Allchorne et al., 2017; Stevens & Mulsow, 2006). As such, it is clear that although there may be undesirable consequences from consuming television, the field is still working to determine whether it is the amount consumed, the type of content, the age of the research participants, or any other number of factors that are driving some of the results found in the current literature. The current study focuses on a burgeoning area of this literature by exploring the association between exposure to fast and slow-paced television and subsequent performance on measures of attention and executive functioning.

The results of this study generally support the hypothesis that pace of programming influences attention and executive functioning immediately after watching television. In addition, two domains (ANT Alerting and ANT Executive Control) showed group by pace interactions. However, the effects were non-significant and small across all outcome measures and were unexpectedly reversed for children with ADHD in one domain (ANT Executive Control), such that they did worse after watching the slow-paced video. Further, the baseline measures of attention and executive functioning generally provided mixed results regarding the hypothesis that Typically Developing children will perform better than children with ADHD. Across the baseline and post-video measures, there were also important effects for the covariates: Internalizing Problems and IQ. These expected and unexpected results, and possible explanations for the findings, are discussed herein.

ADHD and Measures of Attention and Executive Functioning

The first aim of the current study was to examine whether a diagnosis of ADHD influences performance on measures of attention and executive functioning (before watching any television). On the majority of these initial measures, there was a non-significant but small effect of a diagnosis of ADHD (except on the measure of set-shifting abilities from the Trail Making Test, the difference between Trails B and Trails A). However, although the effect of ADHD went in the expected direction on Trails A, Trails B, and Antisaccade Response Suppression, it went in the opposite direction on Antisaccade Task Switching.

One possible explanation for this unexpected finding has to do with the very nature of what Task Switching measures. Task switching on the antisaccade task is conceptualized as the ability to hold two sets of instructions at the same time (hold the rules of the mixed set and hold the rules of the single, static set) and still perform the correct task in response to a cue (Bialystok et al., 2006). In the current sample, the children with ADHD actually had less of a cost (Task Switching = -67.18) for engaging in task switching than did the Typically Developing children (Task Switching = -43.92). Indeed, both groups did better in the mixed trials (compared to the blocked trials) – but the children with ADHD were even slightly faster in the mixed trials. One consideration for this finding is that the mixed trials may serve to keep the attention of the children better. That is, perhaps the unknown stimulus of a mixed block is more “exciting” than the expected stimulus in a static block. Because children with impulsivity may seek out novel stimulation, a child with ADHD may find the changing nature of the mixed blocks more stimulating, and therefore may focus more during this administration. Conversely, they may find the static presentations boring and consequently "zone out" during these blocks. In addition, although the effect of ADHD went in the expected direction for Response Suppression, there was also an unexpected finding. Response Suppression is considered the cost of performing an antisaccade response and overriding the customary saccade, and thus we would expect to see a larger number here indicating that they had more trouble following the rules for antisaccade. However, the Typically Developing children (Response Suppression = -17.44) appear to get a benefit from performing the antisaccades in comparison to the children with ADHD (Response Suppression = 11.48). Although unexpected, similar reversals have been found in previous work (Bialystok et al., 2006), and prior studies have also reported inconsistent results when examining pro- and anti-saccades in children with and without ADHD (Aman, Roberts, & Pennington, 1998; Rothlind, Posner, & Schaughency, 1991).

Regarding the Trail Making Tests, there was a non-significant but small effect for ADHD on Trails A and B, but not for the difference between their raw scores. Somewhat interestingly, the two groups do indeed have different means on the difference between raw scores: ADHD = 104.24 seconds; Control = 80.67 seconds; however, between the small sample size and the inclusion of covariates, there is no effect for ADHD. Although there were effects for IQ on all baseline measures except Antisaccade Response Suppression, this is the only case where ADHD did not also have an effect. This study replicates a previous finding by Robinson & Tripp (2013) which showed that children with ADHD differed significantly from a control group on a measure of IQ (Wechsler Intelligence Scale for Children, Third Edition) but not on the Trail Making Test. The role of IQ as a covariate across our baseline and outcome measures is one of the important contributions this study makes to the literature, and will be discussed further below.

The Impact of Video Pace and ADHD-Status on Measures of Attention and Executive Functioning

The primary goals of this study were to examine the influence of video pace on attention and executive functioning and the possible influence of ADHD-status on these outcomes. Although previous experimental work examining the pace of content and attention/executive functioning has included gender and/or age in their analyses (Anderson et al., 1977; Cooper et al., 2009; Lillard & Peterson, 2011; Wright et al., 1984), this is the first project to include ADHD status as a primary variable, and IQ and Internalizing Problems as covariates. Of note, gender, age, and overall media use were also considered as possible covariates in the current study, but were not included as they did not significantly differ across groups. There was a small but non-significant effect for pace across all the outcome measures (ANT Alerting, ANT Orienting, ANT Executive Control, and Stop Signal). Regarding ADHD, there was a non-significant but medium effect on ANT Executive Control and Stop Signal, and no effect for ANT Alerting or ANT Orienting. There were also non-significant but small ADHD by pace interactions for ANT Alerting and ANT Executive Control. Finally, there were also effects ranging from small to large for the covariates IQ and Internalizing Problems on all outcome measures aside from ANT Orienting, where there was only a small effect of IQ and no effect for Internalizing Problems. The findings for the covariates were all non-significant, aside from Internalizing Problems on the ANT Alerting Network.

Main effects of pace and ADHD. Although the effect size for pace on ANT Orienting was small ($p\eta^2$ = .010) and non-significant, this finding is in line with work by Cooper et al. (2009), which also found an effect of pace on this attentional network (specifically, an interaction between speed of editing and age); thus, the evidence continues to suggest that pace of programming is associated with the efficiency of the orienting attentional network. Interestingly, it should also be noted that while the Orienting network was less efficient for both groups after watching the fast-paced video, Typically Developing children actually did worse than children with ADHD after watching both videos. The finding was not significant and the partial eta for ADHD is below the threshold for even a small effect (p = .817, $p\eta^2$ = .002), but this result suggests that future work should further explore this unexpected outcome. One possibility may align with Cooper et al.'s explanation for their unexpected age by pace interaction (2009). Just as they note that there may be something beneficial about fast-paced videos for 4-year-olds in terms of the Orienting network, one could theorize that there is something beneficial about slow *or* fast-paced television for children with ADHD on this domain. Perhaps watching the cartoon at either pace primed them to attend to the target stimuli on the television (i.e., the main speaking character in each shot), which in turn sets them up to perform well on the Orienting Network – a measurement of efficiency in directing attention to a target stimulus. Whereas Typically Developing children may be able to orient relatively well in many conditions, and thus may not benefit from the "practice" of watching television, children with ADHD typically struggle here, and may receive an added benefit of practicing attending to stimuli prior to task administration. However, as Cooper et al. (2009) noted, there is a potential caveat to this finding: higher orienting scores (which are typically interpreted as a less optimized Orienting network), may actually show efficient use of the spatial cue (Fan & Posner, 2004). Given this potential flaw in the ANT, the current study made use of an additional outcome measure: the Stop Signal Task.

Although the ANT has previously been used to examine the effect of pace on attention (Cooper et al., 2009) and other studies have utilized a variety of Executive Functioning measures (Lillard et al., 2015; Lillard & Peterson, 2011) the current study is the first to examine this potential relationship with the Stop Signal Task. Previous work has shown that children with ADHD display longer stop signal reaction times (SSRT) than control children (Schachar, & Logan, 1990; Schachar, Tannock, Marriott, & Logan, 1995), which aligns with the non-significant medium effect of ADHD in the current study. However, the ANCOVA for SSRT also showed a non-significant but small effect for pace, such that both children with ADHD and Typically Developing children exhibited longer SSRTs after watching the fast-paced cartoon. Similar to the ANT Orienting and Alerting (discussed below) Networks, it appears that fast-paced television has a negative impact on response inhibition. It is conceivable that after watching the fast-paced cartoon, children are primed to expect things to move at a faster pace – and in turn may act and respond quickly to stimuli; as a result, they may experience increased difficulty inhibiting a response. Outside of the laboratory, one could imagine a child working on a complex homework assignment that demands careful thought. If the child has just watched a fast-paced program, he or she may write down the first (possibly wrong) answer that comes to mind instead of evaluating the complete situation and settling on the correct answer. Or perhaps the child heads to a soccer game after relaxing with a few episodes of *SpongeBob SquarePants* and misses a shot on goal when passing to a teammate was the better option; if only she had inhibited the kicking response and instead looked around the field, her team may be up a goal.

Interactions between pace and ADHD. Beyond adding to the growing literature base suggesting the pace of television impacts attention and executive functioning abilities, the current study makes the novel contribution of examining the interaction between ADHD group status and pace for the alerting and executive control attentional networks. Regarding the alerting network, there was a non-significant but small effect such that children with ADHD performed worse after watching a fast-paced video whereas the performance of Typically Developing kids did not differ between slow or fast-paced videos. This finding is especially interesting given that most attentional systems are thought to be relatively intact for children with ADHD – except for the alerting function (Mullane et al., 2011; Nigg, 2006). As described by Nigg (2006), there are several real-world examples of alerting attention, including a radar operator watching a screen for incoming missiles, and a defensive football player awaiting the next play by the offense. The findings of the current study suggest that this network may be negatively impacted after children with ADHD watch fast-paced content. Although most children are likely not operating radar to prevent a missile attack, many play a wide variety of sports. A child who unwinds with a fast-paced cartoon before going to a baseball or football game may perform more poorly than if he or she had watched something more slow-paced (or likely engaged in an entirely different, non-screen activity such as drawing – although a control group of this type was not included in the current study). Expanding this idea even further, as this hypothetical child grows older, he or she may eventually be asked to watch tape of opponents or their own previous performance prior to practice or a game. Unbeknownst to the coach, if the player has ADHD this may have a negative consequence – at least in terms of the alerting network of attention.

Similar to the Alerting Network, examination of the group by pace interaction for the Executive Control Network showed there was a non-significant but small effect of pace for children with ADHD but no effect for Typically Developing children. However, whereas the effect of pace went in the expected direction for the Alerting Network, it was reversed here, such that the Executive Control Network was more efficient for children with ADHD after watching the fast-paced video. This finding is again in line with Cooper at al. (2009), who showed that for some groups fast pace can be beneficial on ANT tasks (although, their grouping variable was age and the network was Orienting). Nonetheless, it is intriguing to think of the possibility that fast pace is not completely detrimental to children's attentional abilities. Just as some types of programming, such as educational content designed for preschoolers, can have beneficial effects for children (Baydar, Kagitcibaci, Kuntay, & Goksen, 2008; Linebarger, Kosanic, Greenwood, & Doku, 2004), perhaps certain kinds of pacing can be advantageous for particular groups of children. Somewhat similar to the hypothesis noted above for the Orienting Network, it is possible the children with ADHD are "primed" to use mental resources to manage cognitive load after watching the fast-paced video; that is, they get practice resolving the conflict between the changing images during a fast-paced television show. Although it seems normal to most people after years of watching television and movies, the shifting images that occur during edits are extremely unnatural: one second a character's face is taking up the whole screen, the next moment he continues to talk but is standing next to someone else in an empty classroom, and immediately thereafter we see a different group of people walking through the jungle. Our brains must resolve the inherent conflict in these shifting images in order to make sense of the narrative. Thus, perhaps the fast-paced cartoon gave the children with ADHD even more "practice" managing this conflict – which may come naturally and more easily for Typically Developing children – and they therefore displayed a more efficient executive control network.

Clearly, there is a link between the pace of television and attention and executive functioning. However, as noted above, the effect of pace was small and non-significant on every outcome measure and occasionally went in the direction opposite expectations. These small effects are especially noticeable when compared to those found in the four studies by Lillard and colleagues (3 from Lillard et al. 2015 and 1 from Lillard & Peterson, 2011). For three of the four, they found a medium to large effect size for pace, ranging from $p\eta^2 = .06$ to $p\eta^2 = .17$. Obviously, the effect sizes for pace reported in the present study fall well short of these levels. However, the authors note that the fantastical events present in the majority of the studies may have further impacted the children's performance on Executive Functioning measures beyond just the effect of pace (Lillard et al., 2015; Lillard & Peterson, 2011). Therefore, in the fourth study (Lillard et al., 2015) they used four different shows to examine both fantasy content and pace (Realistic Shows: *Little Bill* [slow] and *Phineas and Ferb* [fast]; Fantastical Shows: *Little Einsteins* [slow] and *SpongeBob SquarePants* [fast]). Using a Two (pace; fast vs. slow) x two (content; fantastical vs. realistic) ANCOVA for posttest executive functioning, with pretest executive functioning as a covariate, they found an effect for content ($p = .03$, $p\eta^2 = .06$), but no effect for pace or the pace x content interaction; the same analysis examining working memory produced similar results: an effect for content ($p = .02$, $p\eta^2 = .08$) but not for pace. Whereas the authors note that these findings may suggest that fast-paced content is not detrimental to children when the content is realistic, it is important to remember that these are not the only potential variables at play. While pace and fantastical content certainly vary between the shows, they are unable to account for everything else: characters, humor, plot, sound effects – even whether perhaps one show is "boring" while the rest are "exciting." In fact, the authors admit this confound in the introduction, stating, "although there is benefit to using shows that children can actually watch in their real lives, experimental control is sacrificed, leaving open the possibility that results are driven by features other than those intended" (Lillard et al., 2015, p. 794). Thus, the current study removes these additional "features" found in these real-world shows and instead uses the exact same footage in the fast and slow-paced conditions. Therefore, not only does it seem plausible, but also likely, that the effect sizes in this project are somewhat lower than in studies where a variety of factors beyond pace may be influencing the results.

Although the current study eliminated many of the confounds found in the extant literature, we of course have covariates as well: specifically, both IQ and Internalizing Problems varied among the groups. Given the previously-established links between exposure to television and lower IQ scores (Ridley-Johnson, Cooper, & Chance, 1983) and between intelligence and different types of attention (Schweizer, Moosbrugger, & Goldhammer, 2005), one might assume that IQ could serve as some kind of beneficial buffer, such that higher IQ would be associated with better performance on the outcome measures. However, by examining the correlation table, it is clear that although this is true for some measures (Stop Signal, ANT Alerting), it is surprisingly not for all (ANT Executive Control and Orienting). Importantly, between the small sample size and the non-significant correlation, it is difficult to tell how much emphasis to place on the direction of the correlation. Nonetheless, it is tempting to wonder whether the effects of fast-paced programming, and exposure to TV in general, are overriding any potential "benefit" of IQ in some areas of attention and executive functioning.

A similar issue arises for Internalizing Problems, in that the direction of the non-significant correlations are negative for the three ANT networks but positive for the Stop Signal. Although surprising, the fact that Internalizing Problems can have fluctuating links with measures of attention and executive functioning is not completely unexpected. In fact, this finding aligns with previous work that suggests anxiety (a core component of Internalizing Problems) can have adverse effects on some attentional domains (inhibition and shifting), but may not negatively influence other areas, such as quality of performance (Eysenck, Derakshan, Santos, & Calvo, 2007). Although the current study did not aim to examine the additional roles of individual characteristics beyond ADHD status, it is clear that future work should move closer to investigating the whole child in the context of television exposure. As noted in the recent systematic review (Kostyrka-Allchorne et al., 2017), the bulk of work examining television and attention/executive functioning does not examine a host of individual and family characteristics that may be influencing the research findings. By including covariates (IQ and Internalizing Problems) that have yet to be examined in previous studies, the current project moves a step toward fixing this problem. However, it is clear that future work should examine these and additional relationships even further.

Limitations and Future Directions

Although this project makes a novel contribution to the field, there are several study limitations that should be addressed. First, the sample examined in this pilot study is relatively small, and measured power was therefore low (.26; Faul, Erdfelder, Buchner, & Lang, 2009; Faul, Erdfelder, Lang, & Buchner, 2007). As a result, and as noted above in the

Data Analysis section, results were discussed in terms of effect sizes as opposed to significance levels. However, it should still be noted that there were null effects for most findings. Although the evaluation of effect sizes alone is an acceptable method for interpretation of pilot study results (Moore, Carter, Nietert, & Stewart, 2011), it also means that we may truly be discussing "null effects;" that is, until this work is replicated with a larger sample size, it is possible that the current study may be over- (or even under) stating the impact of pace on children's attention and executive functioning abilities. Based on the magnitude of the small effects in the current study, to determine whether these effects are, indeed, significant, future work would need to recruit a sample of 181 participants to achieve statistical power of .80. If these effects indeed replicated and held in a well-powered study, more definitive advice could be provided to parents about the effects of TV pacing.

Second, the ANT, antisaccade task, and Stop Signal Task all suffered from technological and participant difficulties. For the ANT, data were missing due to technical difficulties with the data collection software for three Typically Developing participants and three ADHD participants. Regarding the antisaccade task, there were similar data collection difficulties for one control participant and three ADHD participants. In addition, there were technical difficulties (i.e., program froze) for two ADHD participants, and three ADHD participants refused to complete the task (two participants were unable to remain seated during task administration [with one noting, "you told me that when we were talking that I didn't have to answer questions or do things that make me feel uncomfortable, and I am not doing this"], and one experienced a migraine midway through the task). Finally, one ADHD participant also refused to complete the Stop Signal Task. These types of issues are not uncommon; in fact, during the most recent similar study (Lillard et al., 2015), data was lost for similar reasons: experimenter error, noncompliance, experiment interruption, and video malfunctions. Thus, this lead to the third study limitation: missing data. The current study managed missing data with pairwise deletion, one of the most common strategies used - particularly when conducting a series of ANOVAs (Peugh & Enders, 2004). However, future research studies may benefit from utilizing measures that help limit the amount of missing data. For example, a number of short, hands-on, technology-free measures are utilized in the studies conducted by Lillard and colleagues, such as Head Shoulders Knees and Toes, the Tower of Hanoi, and a delay-of-gratification task using marshmallows and Goldfish crackers (Lillard et al., 2015; Lillard & Peterson, 2011). Although they also experienced missing data (as noted above), these active tasks, which do not involve sitting still in front of a computer monitor, may be especially useful when working with a young population who may have symptoms of ADHD.

Fourth, although the current study is the first to use an original video that is similar to content actually available to children (i.e., a cartoon), the manipulation of pace has two limitations. First, the cuts utilized in the videos primarily consist of edits zooming in and out. While this is certainly a typical edit in many television programs, future studies may want to employ additional types of cuts that were not available in the current video editing program (e.g., changes in camera angle). Second, although the fast-paced video in the current study is faster than the one used by Cooper et al. (every 3 seconds vs. every 4 seconds, respectively; 2009), it is not as fast as some episodes of children's programming. For example, *SpongeBob SquarePants* occasionally has cuts approximately every 2 seconds or faster (especially during montage scenes). Therefore, future studies may find an even greater effect if they utilize videos edited at a faster pace.

Finally, although the current study is the first of its kind to use a sample that includes children with ADHD in addition to Typically Developing children, there are several areas for improvement. First, this was not a medication naïve sample. Although none of the Typically Developing children were taking daily medications at the time of their participation, 8 of 17 ADHD participants used medication to help manage their symptoms of ADHD. Second, although we were able to use parent report on the SCARED and PHQ-2 to screen for anxiety or mood disorders, it is possible that some children in our sample have other psychiatric diagnoses. Given the inclusion of Internalizing Problems as a covariate, one can imagine the potential benefits of future studies using a pure Typically Developing control group (with no psychiatric diagnoses) and a pure ADHD group (with no comorbidities, and split into ADHD-I, ADHD-HI, and ADHD-C). However, this may indeed be wishful thinking as comorbidity is incredibly common for children with ADHD (Larson, Russ, Kahn, & Halfon, 2011). Regardless, examination of the *individual* differences that exist within children, whether they be psychiatric diagnoses, intelligence, gender, SES, family characteristics or any of the many other factors, is truly the next frontier for understanding the influence of pace of television on attention and executive functioning (Kostyrka-Allchorne, et al., 2017).

Conclusion

The current study adds to the mounting evidence that pace of programming is associated with children's immediate attention and executive functioning abilities (Cooper et al., 2009; Kostyrka-Allchorne, et al., 2017; Lillard & Peterson, 2011; Nikkelen et al., 2014). However, the small effects were non-significant, not consistently in the direction expected, and were not the same across groups. For decades, behavioral training has been utilized as one of the most effective treatments for ADHD

(Anastopoulos & Barkley, 1990; MTA Cooperative Group, 1999; Pelham & Fabiano, 2008; Pelham et al., 1998). A core component of this training is managing the environment to help the child succeed in a variety of daily tasks at home, school, and everywhere in between. Just as a parent may choose to not let their child eat dessert before dinner (because it's a "reward," because the child might get full, or for a variety of other reasons) so too may a parent decide not to show a certain type of program to their child immediately before engaging in an activity that requires attention and/or executive functioning. Future studies must continue to examine the consequences (both negative and positive) of children's programming, as clearly not all content is created equal.

Footnote:

[1]The analyses were also run without covariates. All findings remained non-significant. In addition, effect sizes remained similar except for the following changes: a medium effect for pace on ANT Alerting; the effect of ADHD is small and there is no effect of pace on ANT Orienting; there is no effect for the interaction or ADHD on ANT Executive Control. There were no changes for Stop Signal Reaction Time.

Table 1

Diagnostic criteria for ADHD

Inattention

1. Often fails to give close attention to details or makes careless mistakes in schoolwork, work, or other activities
2. Often has difficulty sustaining attention in tasks or play activities
3. Often does not seem to listen when spoken to directly
4. Often does not follow through on instructions and fails to finish schoolwork, chores, or duties in the workplace (not due to oppositional behavior or failure to understand instructions)
5. Often has difficulty organizing tasks and activities
6. Often avoids, dislikes or is reluctant to engage in tasks that require sustained mental effort (such as schoolwork or homework)
7. Often loses things necessary for tasks or activities (e.g., toys, school assignments, pencils, books or tools)
8. Often easily distracted by extraneous stimuli
9. Often forgetful in daily activities

Hyperactivity/Impulsivity

1. Often fidgets with or taps hands or feet or squirms in seat
2. Often leaves seat in situations when remaining seated is expected
3. Often runs about or climbs excessively in situations in which it is inappropriate (in adolescents or adults, may be limited to feeling restless)
4. Often unable to play or engage in leisure activities quietly
5. Often "on the go," acting as if "driven by a motor"
6. Often talks excessively
7. Often blurts out an answer before a question has been completed
8. Often has difficulty awaiting turn
9. Often interrupts or intrudes on others (e.g., butts into conversations or games).

Table 2

Sample Demographic Characteristics

	M (SD) or Percentage	
	Children with ADHD (*N* =17)	Typically Developing Children (*N* = 24)
Age (years)	9.59 (2.58)	9.67 (1.79)
Gender		
Male	64.7%	66.7%
Female	35.3%	33.3%
Race/Ethnicity		
White	94.1%	87.5%
Other/Multiracial	5.9%	4.2%
Declined to Answer	0%	8.3%
Socioeconomic Status (Hollingshead Index)	7.47 (1.42)	7.13 (1.40)
Full Scale IQ	108.47 (13.79)	121.75 (10.53)
Current Media Use: Screen Only (Minutes/week)	492.76 (388.99)	330.29 (353.87)
Current Media Use: Screen & Books (Minutes/week)	593.06 (414.84)	503.31 (321.13)

Table 3

Number of Ineligible Individuals

Reason	*N*
Elevated levels of anxiety[a]	11
Potential ADHD, but did not meet severity level for ADHD problems[b]	11
Refused after completion of the eligibility questionnaire	4
Fell out of age range	1
Indication of experiencing a depressive episode	5
Total number of ineligible individuals	32

[a]As indicated by a score above clinical threshold on the SCARED.
[b]As indicated by < 90% on the ADHD Home Rating Scale.

Table 4

Descriptive Statistics for Visit 1 (Pre-video) Primary Study Variables

	Children with ADHD			Typically Developing Children		
	N	Mean	SD	*N*	Mean	SD
1. ADHD RS-IV: I (percentile)	17	94.47	4.47	24	36.67	25.51
2. ADHD RS-IV: HI (percentile)	17	89.00	12.76	24	34.13	26.44
3. ADHD RS-IV: T (percentile)	17	94.59	4.23	24	34.30	20.30
4. ADHD RS-IV: Symptoms	17	11.00	4.23	24	.79	1.28
5. CBCL Anxious/Depressed	17	58.53/5.00	8.65/4.23	24	53.71/2.63	5.61/2.73
6. CBCL Withdrawn/Depressed	17	56.00/1.88	7.71/2.37	24	53.54/1.13	5.49/1.65
7. CBCL Somatic Complaints	17	55.35/1.65	6.48/2.00	24	53.71/1.08	5.85/1.77
8. CBCL Social Problems	17	57.94/4.00	6.22/2.45	24	52.42/1.38	4.38/2.12
9. CBCL Thought Problems	17	64.65/5.41	6.75/2.79	24	52.63/1.21	4.49/1.59
10. CBCL Attention Problems	17	69.41/10.94	9.89/4.08	24	52.08/2.42	19.8/1.91
11. CBCL Rule Breaking Behavior	17	56.12/2.88	5.79/2.67	24	52.75/1.33	3.33/1.40
12. CBCL Aggressive Behavior	17	61.94/10.29	10.27/7.36	24	51.50/2.63	3.01/2.60
13. CBCL Depressive Problems	17	58.76/3.12	7.16/2.52	24	52.17/.833	3.51/1.09
14. CBCL Anxiety Problems	17	59.65/2.88	8.75/2.45	24	54.21/1.29	5.90/1.68
15. CBCL Somatic Problems	17	55.29/1.12	7.23/1.65	24	54.17/.833	6.47/1.47
16. CBCL ADHD Problems	17	67.29/9.18	7.28/2.88	24	52.13/2.42	3.06/2.08
17. CBCL Opp. Def. Problems	17	61.35/4.47	10.01/3.18	24	53.00/1.63	3.95/1.76
18. CBCL Conduct Problems	17	57.47/3.65	7.49/4.15	24	52.38/1.08	3.62/1.32
19. CBCL Internalizing Problems	17	55.88/8.53	10.10/5.85	24	47.88/4.83	11.11/5.12
20. CBCL Externalizing Problems	17	72.47/13.18	28.11/9.79	24	46.29/3.96	7.44/3.46
21. CBCL Total Problems	17	61.88/47.82	7.92/22.32	24	46.83/16.71	7.82/12.31
22. Trail Making Trails A (seconds)	17	59.06	33.64	24	42.42	17.84
23. Trail Making Trails B (seconds)	17	163.29	59.72	24	123.08	58.55
24. Trail Making Trails B – Trails A (seconds)	17	104.24	51.51	24	80.67	55.86
25. Antisaccade Response Suppression (milliseconds)	9	11.48	82.87	23	-17.45	130.01
26. Antisaccade Task Switching (milliseconds)	9	-67.18	102.35	23	-43.92	109.60

Note. CBCL Data is presented as T-score/Raw score. ADHD RS-IV: I= ADHD Rating Scale – IV: Inattention. ADHD RS-IV: HI= ADHD Rating Scale – IV: Hyperactivity-Impulsivity. ADHD RS-IV: T= ADHD Rating Scale – IV: Total. ADHD RS-IV: Symptoms= ADHD Rating Scale – IV: Total Symptom Endorsements

Table 5

Descriptive Statistics for Visit 2 (Post-video) Primary Study Variables

	Slow Pace				Fast Pace			
	Children with ADHD		Typically Developing Children		Children with ADHD		Typically Developing Children	
	N	*M (SD)*	*N*	*M (SD)*	*N*	*M (SD)*	*N*	*M (SD)*
1. ANT Alerting Network	7	69.33 (87.56)	9	89.78 (68.86)	6	135.46 (35.40)	12	96.97 (49.36)
2. ANT Orienting Network	7	23.43 (44.98)	9	29.88 (48.11)	6	27.49 (59.90)	12	40.79 (46.28)
3. ANT Executive Control Network	7	89.24 (64.68)	9	72.51 (55.82)	6	67.86 (62.53)	12	67.98 (50.03)
4. Stop Signal Reaction Time	7	345.44 (49.37)	12	279.89 (58.81)	8	399.59 (249.89)	12	298.22 (80.23)

Note. All times presented in milliseconds.

Table 6

Correlations among Primary Study Variables for Full Sample

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. ADHD Group Status	—												
2. WASI-II IQ	.49**	—											
3. CBCL Internalizing Problems	-.33*	-.41**	—										
4. Pace	-.03	-.09	-.15	—									
5. Trail Making Trails A	.35*	.33*	-.16	-.10	—								
6. Trail Making Trails B	.40**	.57**	-.37*	-.04	.27	—							
7. Trail Making Trails B – Trails A	-.22	-.29	.27	-.04	.11	-.85**	—						
8. Antisaccade Response Suppression	-.11	.03	-.08	.13	-.28	-.24	.17	—					
9. Antisaccade Task Switching	.10	-.13	.14	.01	-.26	-.28	.25	.23	—				
10. ANT Alerting Network	-.05	-.25	-.33	.23	-.43*	-.03	-.04	-.09	.37	—			
11. ANT Orienting Network	.11	.14	-.03	.10	-.23	-.05	-.03	.32	.40*	-.19	—		
12. ANT Executive Control Network	-.09	.19	-.15	-.11	-.09	-.23	.38*	.04	-.06	.10	.21	—	
13. Stop Signal Reaction Time	-.32*	-.30	.08	-.14	-.48**	-.42**	.23	.23	.08	.26	-.07	.32	—

Note. * = $p < .05$, ** = $p < .001$.

Table 7

Effect Sizes and Significance Levels for Visit 2 (Post-video) Primary Study Variables

	Large Effect	Medium Effect	Small Effect	No Effect
1. ANT Alerting	Internalizing***	IQ**	Pace* ADHD x Pace	ADHD
2. ANT Orienting			Pace IQ	ADHD Internalizing ADHD x Pace
3. ANT Executive Control		ADHD*	Pace IQ* Internalizing* ADHD x Pace	
4. Stop Signal Reaction Time		ADHD*	Pace IQ* Internalizing	ADHD x Pace

Note. * = $p < .3$, ** = $p < .1$, *** = $p < .05$.

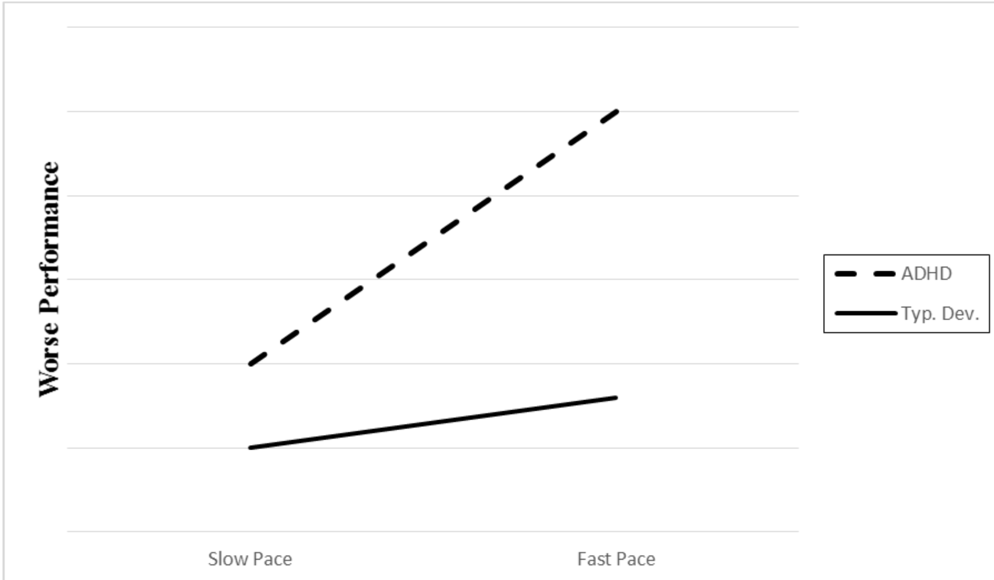

Figure 1. Hypothesized performance on measures of Attention and Executive Functioning.

Figure 2a. Screenshot from an episode of *South Park*

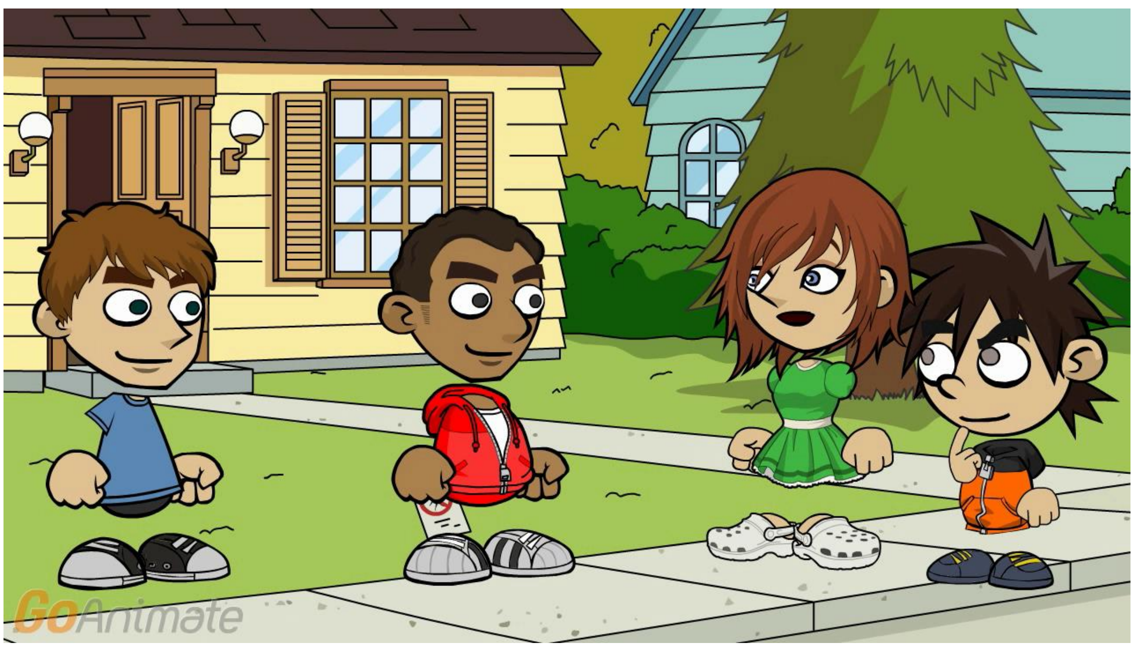

Figure 2b. Screenshot from study video

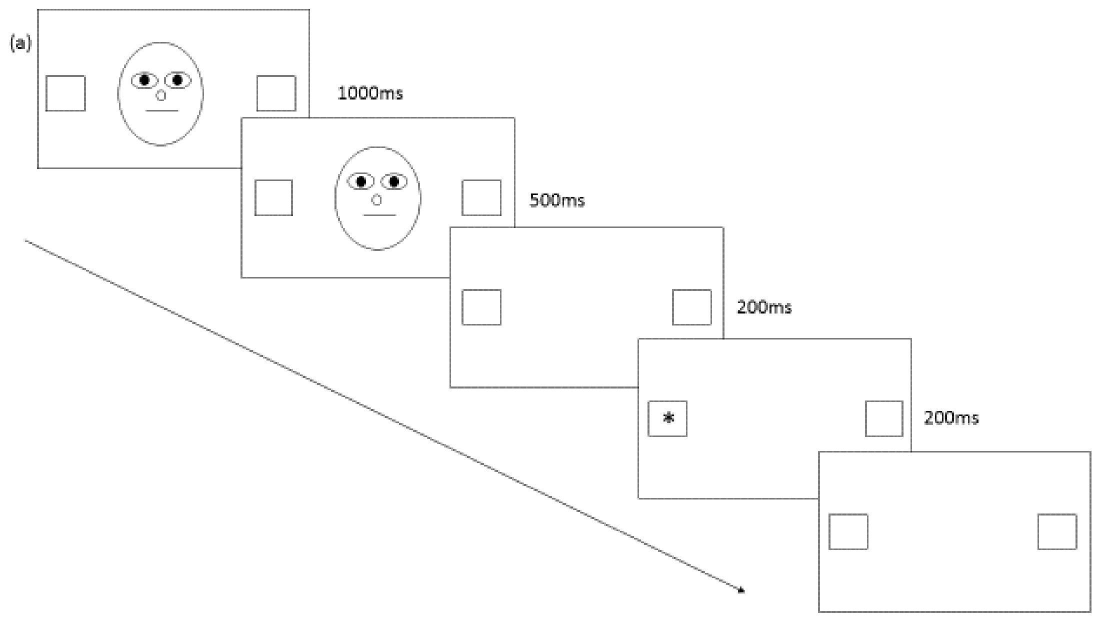

Figure 3. Sequence for antisaccade task

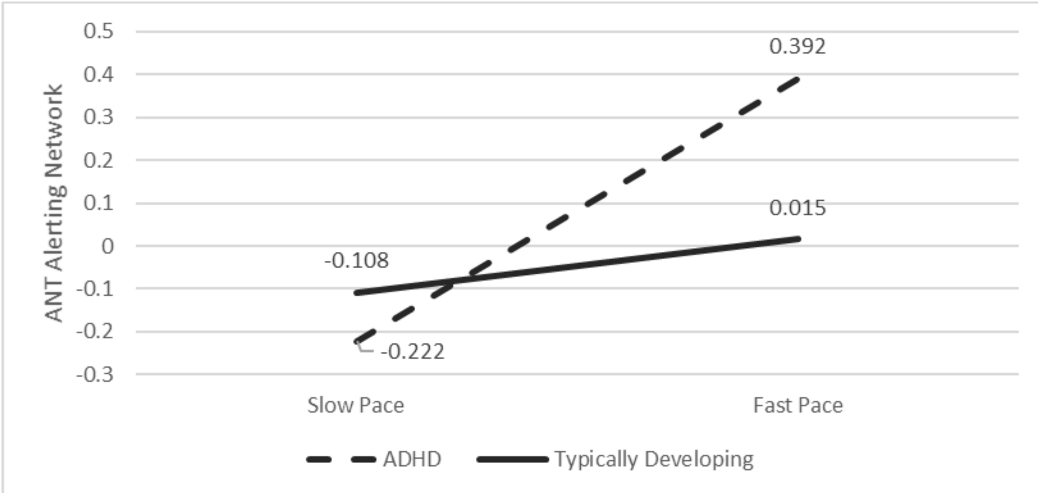

Figure 4. ANT Alerting Network ANCOVA Interaction.
Note. This figure presents the estimated marginal means of ANT Alerting Network standardized scores when including Full Scale IQ and CBCL Internalizing Problems as covariates.

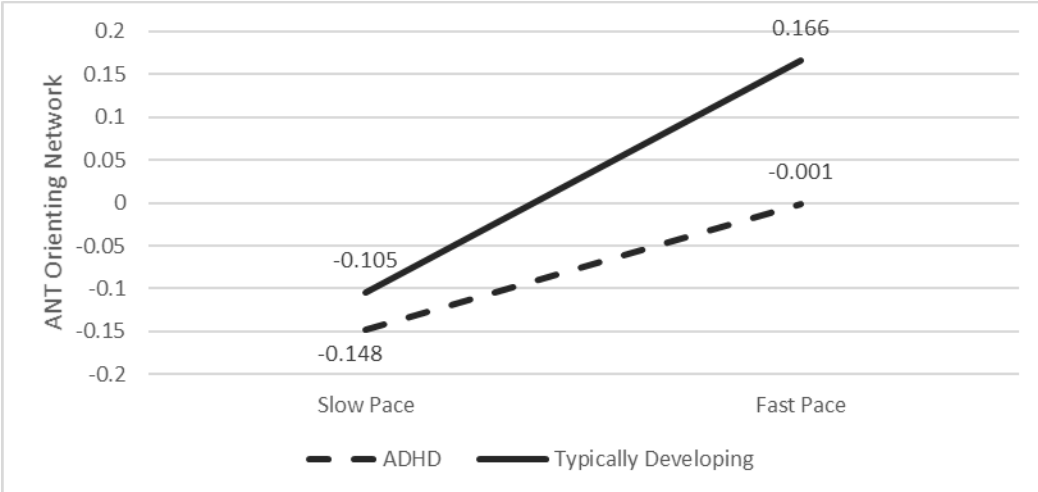

Figure 5. ANT Orienting Network ANCOVA Interaction.
Note. This figure presents the estimated marginal means of ANT Orienting Network standardized scores when including Full Scale IQ and CBCL Internalizing Problems as covariates.

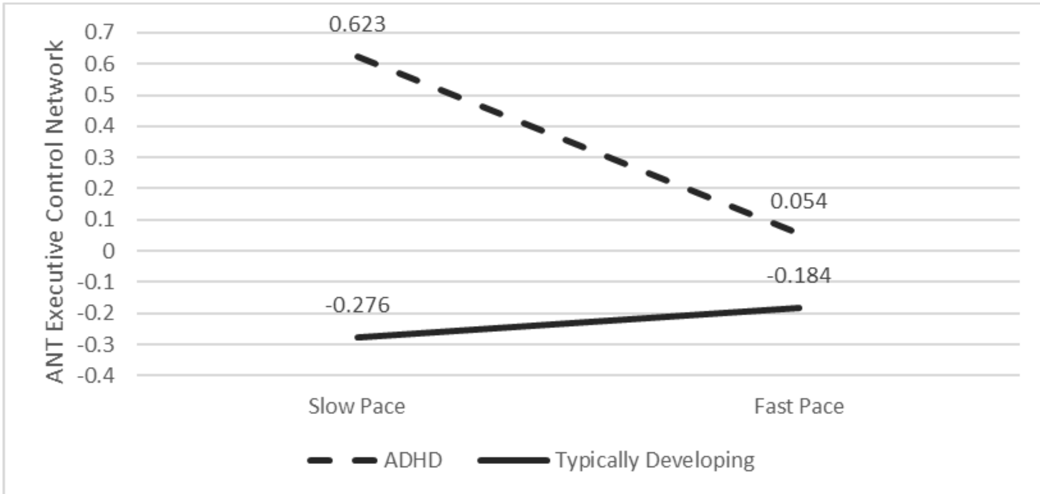

Figure 6. ANT Executive Control Network ANCOVA Interaction.
Note. This figure presents the estimated marginal means of ANT Executive Control Network standardized scores when including Full Scale IQ and CBCL Internalizing Problems as covariates.

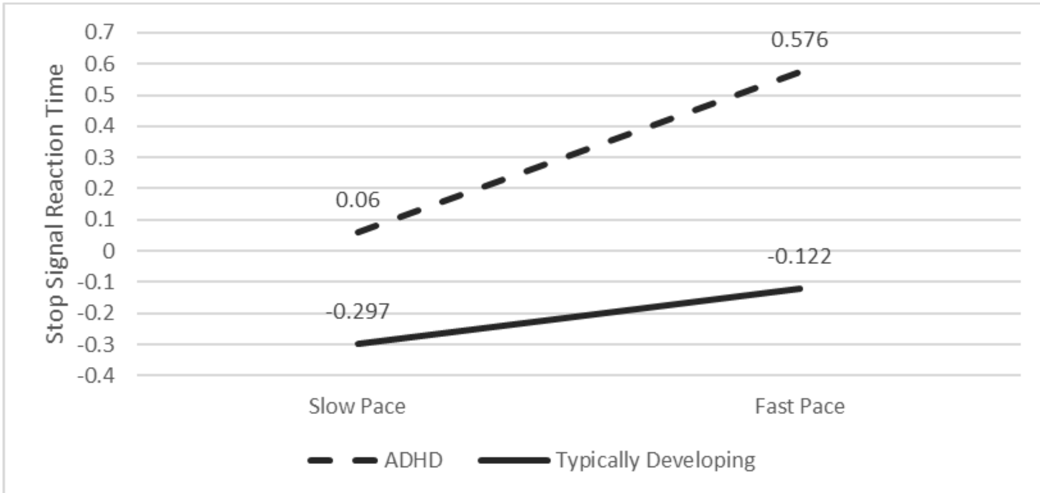

Figure 7. Stop Signal Reaction Time ANCOVA Interaction.
Note. This figure presents the estimated marginal means of Stop Signal Reaction Time standardized scores when including Full Scale IQ and CBCL Internalizing Problems as covariates.

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