

Pragmatic Language Use, Inhibitory Control, and Attention  
in Typically-developing Preschoolers

by

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This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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## Statement of Contributions

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All other contributions were those of the candidate (Ami C. Rints).

## Abstract

Attention-Deficit/Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder that is characterized by atypical levels of inattention and hyperactivity-impulsivity, and which is estimated to affect approximately 5% of school-aged children worldwide (Polanczyk, de Lima, Horta, Biederman, & Rohde, 2007). A growing body of empirical research has sought to better understand the phenotypic behaviours associated with ADHD, including behaviours which are frequently observed but are not required for a diagnosis of the disorder – including a wide range of socio-communicative behaviours which are often impaired within this population. In addition, recent conceptualizations of inattentive and hyperactive-impulsive behaviours have begun to emphasize the dimensional nature of these traits, with the recognition that these traits may be present to varying degrees within normative populations. Within this context, this study sought to explore the extent to which inattention and hyperactivity-impulsivity were related to the communicative abilities of a sample of typically-developing preschool-aged children. More specifically, this research examined whether inattentive and hyperactive-impulsive traits may mediate the impact of weak inhibitory ability upon both the knowledge and application of appropriate pragmatic behaviours in early development. Thirty-six typically-developing preschoolers and their parents provided the data used in these analyses. Parents completed questionnaires assessing children's ADHD-related behaviours, while inhibitory control was measured with children using a distraction task. Pragmatic language was assessed via parent report of children's actual communicative behaviours in their everyday lives (application), and by assessing children's performance on a task asking them about hypothetical social situations (knowledge). Results indicated that individual differences in children's inhibitory control predicted both their knowledge and application of appropriate pragmatic language. Hyperactive-

impulsive behaviours were found to be a significant mediator of this relationship, but only with respect to children's ability to effectively apply pragmatic rules in everyday communicative settings. Taken together, these findings suggest that social communication difficulties in some young children may be a downstream effect of hyperactive-impulsive behaviours which arise from poorly developed inhibitory control.

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## **CHAPTER 1: General Introduction and Literature Review**

The ability to communicate effectively with others is a skill which is crucial for social functioning. Indeed, research in various populations suggests that deficits in pragmatic language – or social communication – are often associated with various other social impairments, including social rejection (Leonard, Milich, & Lorch, 2011; Staikova, Gomes, Tarter, McCabe, & Halperin, 2013; Hemphill & Siperstein, 1990; Conti-Ramsden & Botting, 2004). Successful communication requires competence in pragmatic language, defined as the “use of language within social contexts” (Bates, 1976), and encompasses a number of communicative behaviours such as the ability to attend to and track the content of conversations, respond with on-topic and context-appropriate comments, and ensure the understanding of one’s listener. Important, however, is the recognition that many individuals have difficulty engaging in such behaviours – which may have important implications for their ability to successfully interact with others and engage in important activities in their everyday lives. As such, it is important that research seeks to better understand the extent and nature of pragmatic language difficulties amongst such individuals, including an emphasis on the identification of factors which may be contributing to such difficulties. To the extent that our understanding is enhanced through research, we may be better positioned to develop and implement interventions in order to circumvent any negative outcomes that might result from such communicative impairments.

At the group-level, Attention-Deficit/Hyperactivity Disorder (ADHD) has often been associated with deficits in socio-communicative behaviours in both observational and empirical investigation (for a review, see Green, Johnson, & Bretherton, 2014). Although well-documented, limited research has examined the precise mechanisms which underlie such difficulties. However, there has been a growing interest in the possible contribution of associated

deficits in various executive functions (e.g., Tannock & Schachar, 1996; Purvis & Tannock, 1997; Bignell & Cain, 2007; Nilsen & Fecica, 2011; Green et al., 2014). The present work sought to examine whether traits of inattention and hyperactivity-impulsivity, the core behavioural traits of ADHD, mediated the association between response inhibition – one component of executive functioning – and pragmatic language abilities. Importantly, the present work distinguished between children’s knowledge of appropriate pragmatic behaviours and their ability to effectively apply that knowledge in communicative contexts. This relationship was examined within a sample of typically-developing preschool-aged children, given the normative frequency of inattentive and hyperactive-impulsive behaviours within this age group. In so doing, this research aimed not only to test a specific model which might account for some of the communicative impairments of individuals who possess such traits, but also sought to extend the extant literature to a sample of younger, typically-developing children.

### **1.1 Attention-Deficit/Hyperactivity Disorder and Preschoolers**

Attention-Deficit/Hyperactivity Disorder (ADHD) is a common disorder of development which is estimated to affect approximately 5% of school-age children (Polanczyk et al., 2007).

Characterized by developmentally atypical levels of inattention and hyperactivity-impulsivity, ADHD presents early in development and causes impairment across settings (American Psychiatric Association [APA], 2000). In addition to the inattentive and hyperactive-impulsive behaviours which characterize this disorder, there are several associated features of the disorder which comprise its broader phenotype. These include deficits in other important areas of functioning including, but not limited to, social and emotional development, motor coordination, and skills in executive functioning (see Tarver, Daley, & Sayal, 2014, for a review).

Prior to the age of 6, diagnosis of ADHD is complicated by the fact that the overt behaviour associated with the ADHD phenotype is common within the context of early normative development (Blackman, 1999; Connor, 2002; Mahone & Schneider, 2012; Smidts & Oosterlaan, 2007). Although features of inattentive and hyperactive-impulsive behaviour are often quite transient for many preschool-aged children (e.g., Bunte, Schoemaker, Hessen, van der Heijden, & Matthys, 2014; Palfrey, Levine, Walker, & Sullivan, 1985; see Connor, 2002, for a review), research has suggested that children in this age range do show individual variability in the expression of ADHD traits (e.g., Lahey et al., 2004; Lakes, Swanson, & Riggs, 2012). Furthermore, research has suggested that more severe symptomatic presentation early in development may predict stability in ADHD traits over time (Pierce, Ewing, & Campbell, 1999). Longitudinal studies provide some evidence of the temporal stability of ADHD traits in children diagnosed during the preschool years, with one study finding that as many as 80% of children who met full diagnostic criteria between the ages of 4 and 6 subsequently met diagnostic criteria over the course of the next three years (Lahey et al., 2004; although also see above regarding symptom transiency).

In addition to attempting to elucidate the prevalence and trajectory of ADHD traits within the preschool population, researchers have become increasingly interested in associated features of the disorder that manifest early in development (Cunningham & Boyle, 2002; Wilens et al., 2002; DuPaul, McGoey, Eckert, & VanBrakle, 2001). Importantly, inattention and hyperactivity-impulsivity have been linked with several important functional implications within the preschool population regardless of children's diagnostic status. These include higher rates of unintentional injury, increased placements in special education settings, and lower levels of teacher-rated academic achievement and scores on assessments of pre-academic skills (Lahey et al., 2004;

DuPaul et al., 2001). In addition, children with higher levels of these traits also present with a number of social difficulties, including adversely affected parent-child interactions, more self-reported difficulties developing and maintaining friendships, and being rated as less socially competent relative to same-aged peers (Lahey et al., 2004; DeWolfe, Byrne, & Bawden, 2000; DuPaul et al., 2001). Notably, higher levels of impairment are associated with ADHD traits even in those preschool-aged children who do not fully meet diagnostic criteria (i.e., those who do not demonstrate impairment across multiple settings; Lahey et al., 2004).

## **1.2 Pragmatic Language/Social Communication**

Within the pragmatic language domain, a number of interrelated skills have been identified as critical to successful participation in communicative exchanges. The American Speech-Language-Hearing Association (n.d.) recognizes these communicative skills as comprising three main categories. These include: the ability to use language for different purposes, such as greeting others or communicating wants and needs through making requests; the ability to adjust language according to the needs of the listener or situation, such as speaking differently to children versus adults or in formal versus peer settings, and providing sufficient background information to facilitate the listener's understanding; and the ability to follow the rules for various communicative acts, such as conversational turn-taking, rephrasing information when one has been misunderstood, and making appropriate use of nonverbal signals such as eye gaze and facial expression. Previous research has suggested that pragmatic language skills develop rapidly within the context of early normative development (O'Neill, 2007), with typically developing children readily mastering a number of verbal and nonverbal behaviours thought to underlie successful communication early in childhood (see Nilsen & Fecica, 2011, for a brief review).

### **1.2.1 Social Communication in ADHD**

Among the associated features of the disorder, individuals with ADHD often present with a number of communicative deficits (Camarata & Gibson, 1999; Geurts et al., 2004; Staikova et al., 2013; Green et al., 2014). In addition to those behaviours directly reflected in the diagnostic criteria, such as having difficulty attending when spoken to directly and with talking excessively (APA, 2000; Tannock & Schachar, 1996; Camarata & Gibson, 1999), researchers working with this population have identified patterns of additional pragmatic deficits amongst those with ADHD-related traits across a number of performance-based, parent- and teacher-reported, and observational measures of communicative abilities.

For example, narrative telling tasks, which require participants to either generate or retell stories, have been used extensively in the pragmatic language literature to assess pragmatic competence (Botting, 2002), given the importance of narrative abilities to communicating information to others across a number of settings (Tannock, Purvis, & Schachar, 1993). In one story-telling task comparing their performance to normative controls, 7- to 11-year-old boys diagnosed with ADHD demonstrated poorer organization and monitoring of their verbal productions, despite comparable levels of comprehension of the story, when asked to retell a previously unfamiliar folk tale after an initial exposure (Purvis & Tannock, 1997). Children with ADHD tended to make more sequencing errors and provided more ambiguous statements, and were also more likely to convey inaccurate information and use inappropriate words in their retelling of the narrative. These results are consistent with another study using a narrative task, which also found that in addition to issues with organization and monitoring, school-aged boys with ADHD also tended to provide less information overall when retelling two stories (Tannock et al., 1993). Again, these differences in retelling the stories were evident when comparing the

performance of boys with ADHD to typically-developing boys despite comparable abilities to comprehend and identify the main ideas from the stories (Tannock et al., 1993), and have the net effect of making their narratives more difficult for listeners to understand. While narrative tasks require these children only to assume one role – i.e., as purveyors of information – children with ADHD likewise demonstrate pragmatic deficits when required to alter their communicative patterns dependent on changing roles in social interactions (Landau & Milich, 1988; Whalen, Henker, Collins, McAuliffe, & Vaux, 1979; Kim & Kaiser, 2000). For example, when compared to normal controls in a semi-structured role-playing task, boys with ADHD were less able to appropriately adjust their communication when transitioning between the roles of interviewer versus interviewee, and indeed, these difficulties with modulating their communicative patterns elicited poorer communicative behaviour from the normal controls with whom they were interacting (Landau & Milich, 1988).

In addition, an accumulating body of research regarding referential communication abilities within the ADHD population also points to the pragmatic limitations of this group. Referential communication refers to how words and phrases are used to denote objects and events in our world, and is a pragmatic ability which relies heavily on an individual's ability to attend closely to the other's perspective in order to effectively provide and make sense of information in order to facilitate understanding (Nilsen & Graham, 2009). Studies assessing referential abilities often take the form of tasks which require one individual to provide adequate instructions in order for the listener to effectively complete some task. In one structured communication task comparing the performance of 'hyperactive' school-aged males to normal controls, hyperactive youth were found to be less able to modulate their language appropriately according to whether they were the person providing instructions to complete a block

construction or if they were the person receiving that information. Indeed, those hyperactive youth were less likely to ask for confirmation that their construction was correct and were more likely to argue with the person providing instructions – despite the fact that they had no objective basis for doing so. They were also more likely to show no change in communicative behaviours when their task role switched, such that their language patterns were similar both in the role of information purveyor and information receiver (Whalen et al., 1979). Likewise, research by Nilsen and colleagues has found that when presented with referential communication tasks, children with ADHD show deficits in their comprehension of informative statements (Nilsen, Mangal, & MacDonald, 2013). Consistent with this, although adults with elevated symptoms of ADHD were equally able to complete a referential task relative to normal controls, they were found to be less efficient than those without such traits in carrying out the task (Nilsen, Mewhort-Buist, Gillis, & Fugelsang, 2013) – highlighting that these traits may continue to have a negative association with pragmatic language skills even into adulthood.

Deficits in pragmatic language skills are also evident when the skills of children with ADHD are assessed via caregiver report measures. Bishop and Baird (2001) found that children with ADHD showed comparable levels of overall communicative deficits (as assessed by the Children's Communication Checklist [CCC; Bishop, 1998, as cited in Bishop & Baird, 2001]) as children diagnosed with Asperger syndrome and Pervasive Developmental Disorder Not Otherwise Specified – diagnoses often associated with pragmatic deficits (.More specifically, children with diagnoses of ADHD were rated as having elevated levels of inappropriate initiation of communication and stereotyped language, including sudden changes in topic, directing conversations toward their egocentric interests, and frequent and occasionally inappropriate use of favourite words or phrases. They were additionally rated as showing poorer rapport building

behaviours, including ignoring others' conversational attempts, not reading facial expressions and tones of voice (thereby missing important emotional cues), and avoiding eye contact. Using a Norwegian adaptation of the Children's Communication Checklist – Second Edition (CCC-2; Bishop, 2003, as cited in Helland, Biringer, Helland, & Heimann, 2012), Helland et al. (2012) found that 6- to 15-year-olds with either ADHD or Asperger syndrome showed significantly more communication impairments than typically developing youth aged 6 to 12 years, finding that 82.1% of the ADHD group and 90.5% of the youth with Asperger syndrome demonstrated communicative impairments compared to 3.6% of typically developing youth. Indeed, these researchers found that the pragmatic language profiles of these two clinical groups only differed based on two subscales of the measure, with children with ADHD showing more skillful use of nonverbal communication (e.g., use of facial expression, eye contact) and fewer instances of stereotyped language (e.g., over-precise pronunciations, use of favourite phrases) than youth with Asperger syndrome. These results are consistent with the findings of Geurts and Embrechts (2008), who found that youth with either ADHD or Autism Spectrum Disorders (ASD) showed higher levels of communication deficits than typically-developing controls on the CCC-2, but that they could not be differentiated from one another when looking at a composite of overall pragmatic competence based on parent and teacher report. Finally, when considering the language profiles of a community sample of preschoolers, researchers found that while several behavioural difficulties are associated with teacher-reported pragmatic competence, including various emotional, conduct, and social behaviours, correlations were strongest for a measure of inattentive and hyperactive behaviours (Ketelaars, Cuperus, Jansonius, & Verhoeven, 2010).

Children with ADHD have also demonstrated more inappropriate pragmatic behaviours compared to typically developing peers when their spontaneous speech is directly observed. In a

study comparing the performance of 6- to 8-year-old children with ADHD to normal controls, Kim & Kaiser (2000) found that children with ADHD produced significantly more inappropriate and significantly fewer appropriate pragmatic behaviours during play with adults, such as failing to respond to questions or requests (i.e., difficulty adjusting to both speaker and listener roles according to context), interrupting others, and providing less feedback to speakers. Interestingly, the groups did not differ when compared on a standardized measure assessing their knowledge of appropriate pragmatic behaviours, suggesting that the pragmatic language deficits found in ADHD may be specific to the ability to execute appropriate pragmatic behaviours in context rather than due to an existing pragmatic knowledge deficit per se (Landau & Milich, 1988).

In addition to considering behaviours associated with the broader diagnostic category, other researchers have highlighted the importance of considering the association between communicative behaviours and ADHD by looking separately at traits of inattention and hyperactivity-impulsivity (Camarata & Gibson, 1999; Bignell & Cain, 2007). In contrast to the research cited above, Bignell and Cain (2007) sought to explore the differential relatedness of inattentive and hyperactive-impulsive symptoms to pragmatic competence in a non-diagnosed, community sample of 7- to 11-year-old children. They found that different pragmatic language profiles were associated with teacher-rated inattentive versus hyperactive-impulsive traits – underlining the importance of considering these behavioural characteristics separately in considerations of pragmatic language functioning (Kim & Kaiser, 2000). While children with either inattentive or hyperactive traits were less likely than matched normative controls to make use of context in interpreting figurative language, higher levels of inattentive but not hyperactive traits were associated with more general deficits on a well-validated measure of communicative competence (Bignell & Cain, 2007). In contrast, when considering these traits in a preschool-

aged sample of clinically-referred children, Geurts and Embrechts (2008) found that symptoms of impulsivity, but not inattention, predicted overall pragmatic competence as measured on the CCC-2. This research provides preliminary evidence to suggest that different pragmatic profiles may be associated differentially with inattentive versus hyperactive-impulsive symptoms depending on the age-range under consideration, and even within the context of typical development.

### **1.3 Executive Functions and Inhibitory Control**

Executive functions are defined as a set of interrelated but separable cognitive skills that facilitate purposeful, goal-directed behaviour (Lezak, 1982; Miyake et al., 2000). Although several different executive components have been postulated and examined within the empirical literature, arguably the three most commonly explored executive functions are: cognitive flexibility or set shifting, monitoring and updating working memory, and inhibitory control (Miyake et al., 2000). Respectively, these are defined as the ability to switch easily between different tasks or mental sets (Monsell, 2003), the ability to hold and manipulate goal-relevant information in mind (Baddeley, 1992), and the ability to withhold prepotent but inappropriate responses within a given context (Nigg, 2001). Recent research suggests that while cognitive flexibility and working memory may take a somewhat more protracted trajectory of development, continuing to show gradual improvements throughout childhood and adolescence (see Best & Miller, 2010), inhibitory control has been found to develop quite rapidly during the preschool period (McAuley, Christ, & White, 2011) with a slower rate of change indicated later on (see Best & Miller, 2010, for a review). Furthermore, deficits in various executive functions have also been observed within a number of atypical populations including amongst individuals with high levels of ADHD traits (Seidman, 2006).

### **1.3.1 Inhibitory Control and ADHD**

Although deficits are found in other aspects of executive functioning, e.g., working memory (Martinussen, Hayden, Hogg-Johnson, & Tannock, 2005), arguably one of the most robust findings to emerge within the ADHD literature is the association between ADHD traits and poorly developed inhibitory control (Lipszyc & Schachar, 2010; Schachar, Mota, Logan, Tannock & Klim, 2000; Tannock & Schachar, 1996). While considerable evidence exists for this within clinical populations, this finding appears true even for individuals who demonstrate traits of the disorder but who do not meet full diagnostic criteria (Berlin & Bohlin, 2002; Sonuga-Barke, Dalen, Daley, & Remington, 2002; Thorell & Wåhlstedt, 2006). Indeed, deficits in inhibitory control have long been suggested to be one of the most predominant and underlying features of ADHD (e.g., Barkley, 1997). More recently, research has sought to elucidate more precisely the nature of the association between inhibitory control and ADHD – endeavouring to understand, for example, whether inhibitory deficits may simply coincide with the presence of ADHD symptoms, or rather may play a causal role in its manifestation. Compelling research is currently amounting in support of the latter view – that is, of inhibitory control as being causally implicated in the disorder. For example, research by Aron & Poldrack (2005) suggests that deficits in inhibitory control are associated with the proposed neurobiological underpinnings of ADHD. In addition, research by Schachar and colleagues suggests that deficits in inhibitory control are evident within families of individuals who present with ADHD (Crosbie & Schachar, 2001; Schachar et al., 2005), and tend to persist regardless of changes in one’s diagnostic presentation (i.e., those whose symptoms and impairment appear to remit; McAuley, Crosbie, Charach, & Schachar, 2014). These findings are consistent with theoretical work proposing inhibitory control more specifically as lying in the causal pathway which links underlying

susceptibility genes to overt manifestations of the ADHD phenotype (i.e., response inhibition as an endophenotype of ADHD; Crosbie, Pérusse, Barr, & Schachar, 2008).

### **1.3.2 Executive Functions/Inhibitory Control and Social Communication**

Although there is growing consensus about the nature and extent of pragmatic deficits associated with ADHD, the mechanisms underlying these difficulties are as yet unclear (Green et al., 2014). As such, there has recently been an increasing interest within the empirical literature on the elucidation of factors which may underlie pragmatic deficits across both typical and atypical development. One area that has begun to receive considerable attention is that of the role of various executive functions, including inhibitory control, in the development and execution of various pragmatic skills. Research has found that response inhibition plays an important role in various aspects of communication in typically-developing samples, including the ability to take another's perspective during communication in both pediatric (e.g., Nilsen & Graham, 2009) and adult (e.g., Brown-Schmidt, 2009; Wardlow, 2013) populations, as well as children's modulation of their own talkativeness during communicative exchanges (Blain-Brière, Bouchard, & Bigras, 2014).

With respect to atypical samples, correlational evidence suggests that inhibitory deficits are often observed amongst populations of individuals with associated pragmatic language difficulties, including ADHD (e.g., Lipszyc & Schachar, 2010) and Autism Spectrum Disorders (e.g., Christ, Holt, White, & Green, 2007). Moreover, several researchers have more explicitly highlighted the likely theoretical importance of less well-developed inhibitory control and other executive abilities in the pragmatic language difficulties often evidenced by those with ADHD (Tannock & Schachar, 1996; Purvis & Tannock, 1997; Bignell & Cain, 2007; Nilsen & Fecica, 2011; Green et al., 2014) – suggesting that the observed pragmatic deficits may be a downstream

consequence of poorly developed inhibitory and other executive skills. To date, however, little empirical work has simultaneously examined the extent to which various executive abilities, ADHD traits, and pragmatic language skills are interrelated within the context of a single study (Green et al., 2014; but see Huang-Pollock, Mikami, Pfiffner, & McBurnett, 2009).

#### **1.4 The Present Investigation**

As reviewed here, research has demonstrated that relationships exist between ADHD traits and inhibitory control, ADHD traits and pragmatic language skills, and pragmatic language skills and inhibitory control – with recent conceptualizations suggesting that while inhibitory control may be causally implicated in the disorder, social language impairments may instead reflect a downstream consequence of ADHD (e.g., Crosbie et al., 2008; Green et al., 2014). Less clear, however, is how these factors may interact simultaneously within the context of earlier typical development and, more specifically, how inhibitory control might be implicated in the pragmatic language deficits often associated with ADHD traits. As such, the present study sought to examine the interrelatedness of these factors within a sample of typically developing preschoolers by assessing a mediational model which, consistent with current thinking regarding the role of response inhibition in the etiology of ADHD (e.g., Crosbie et al., 2008), proposes that inattentive and hyperactive-impulsive traits may mediate the relationship between response inhibition and pragmatic language abilities. Preschoolers were selected given the behavioural consistency between this age group and the ADHD phenotype (e.g., Smidts & Oosterlaan, 2007), as well as the observed rapid development of inhibitory control and pragmatic language abilities early in development (e.g., O’Neill, 2007; McAuley et al., 2011). In addition, while a majority of the extant literature has focused on the association of ADHD traits and communicative abilities within clinical samples, this study will focus instead on the association of these traits within a

normative sample. As pointed out by other researchers (e.g., Bignell & Cain, 2007), one benefit of conducting such research within populations of children without clinically significant difficulties is that the observed relationships amongst the variables are less likely to have been influenced by other behavioural and other conditions which frequently co-occur with ADHD. In addition, contrary to much of the extant literature which has focused on categorical classifications of ADHD in assessments of pragmatic language abilities, this study emphasizes a dimensional view of the core traits of inattention and hyperactivity-impulsivity, consistent with current evidence which suggests that ADHD traits lay on a continuum of normal behaviour (Larsson, Anckarsater, Råstam, Chang, & Lichtenstein, 2012; Levy, Hay, McStephen, Wood, & Waldman, 1997). This appears relevant not only from a theoretical perspective on the phenomenon of ADHD, but also in light of evidence which suggests that inattentive and hyperactive-impulsive symptomatology may be differentially associated with various pragmatic deficits (e.g., Geurts & Embrechts, 2008).

To achieve these goals, a sample of typically-developing preschool-aged children was sampled from a local early childhood education centre and the surrounding community. Children's ADHD-related behaviours were assessed via parent-report questionnaire, while their response inhibition was assessed using a performance-based measure in the research laboratory. Children's knowledge of pragmatic language rules was also assessed using a performance-based measure, while their appropriate use or application of pragmatic language rules in everyday communicative contexts was assessed via parent-report. Analyses were conducted using bias-corrected bootstrap tests of mediation which allowed for testing the hypothesis that inattentive and hyperactive-impulsive traits would mediate the association between response inhibition and pragmatic language abilities. This mediation was expected to be evident primarily with respect to

the measure of children's use of appropriate pragmatic abilities, rather than the measure of children's pragmatic knowledge, given research which suggests that the social communication deficits evident in ADHD may reflect difficulty with the application of intact pragmatic knowledge rather than a knowledge deficit per se (e.g., Kim & Kaiser, 2000).

## CHAPTER 2: Study

Social communication is predicted by inhibitory ability and ADHD traits in preschool-aged children: A mediation model

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Attention-Deficit/Hyperactivity Disorder (ADHD) is a common disorder of development that affects approximately 5% of school-aged children (Polanczyk, de Lima, Horta, Biederman, & Rohde, 2007). Characterized by developmentally atypical levels of inattention and hyperactivity-impulsivity, ADHD presents early in development and causes impairment across settings (American Psychiatric Association [APA], 2000). Prior to the age of 6, diagnosis of ADHD is complicated by the fact that the overt manifestations of the disorder are normative in typically developing preschool-aged children and tend to be transient in this age group (see Connor, 2002, for a review). Nonetheless, research has demonstrated that preschoolers show individual variability in the expression of ADHD traits (e.g., Lahey et al., 2004; Lakes, Swanson, & Riggs, 2012) and that these traits are more temporally stable and impairing in preschoolers who have a more severe symptomatic presentation – even if they do not meet full diagnostic criteria for the disorder (Lahey et al., 2004; Pierce, Ewing, & Campbell, 1999).

Efforts at elucidating the prevalence of ADHD traits in preschoolers have been accompanied by a growing interest in identifying correlates of the disorder that may emerge early in development (Cunningham & Boyle, 2002; Wilens et al., 2002; DuPaul, McGoey, Eckert, & VanBrakle, 2001). In addition to the core traits of inattention and hyperactivity-impulsivity that define ADHD, the broader disorder phenotype includes deficits in other areas of

functioning, including social and emotional development, motor coordination, and executive control (see Tarver, Daley, & Sayal, 2014, for a review). The latter has been the focus of considerable empirical study within the context of ADHD (e.g., Seidman, 2006). One robust finding to emerge from this burgeoning literature is that response inhibition – defined as the ability to withhold highly prepotent but inappropriate behaviours (Nigg, 2000) – is strongly and consistently associated with the disorder. Not only are inhibitory deficits commonly experienced by children who have an ADHD diagnosis (e.g., Lipszyc & Schachar, 2010), but they are also prevalent amongst children with high levels of ADHD traits who do not meet full diagnostic criteria for the disorder, including young, preschool-aged children (Berlin & Bohlin, 2002; Sonuga-Barke, Dalen, Daley, & Remington, 2002; Thorell & Wåhlstedt, 2006). Although inhibitory deficits have thus traditionally been viewed as part of the broader disorder phenotype (Barkley, 1997), more recent theoretical accounts of ADHD have attempted to elucidate the precise nature of this relationship – questioning, for example, whether inhibitory deficits simply co-occur with ADHD or are causally implicated in the disorder. Consistent with the latter view, research has shown that inhibitory deficits are related to the proposed neurobiological underpinnings of ADHD (Aron & Poldrack, 2005), aggregate within families of ADHD probands (Crosbie & Schachar, 2001; Schachar et al., 2005), and persist irrespective of changes in disorder severity – being evident, for example, even in ADHD children who appear to ‘outgrow’ their symptoms and impairment (McAuley, Crosbie, Charach, & Schachar, 2014). This growing empirical basis is consistent with the view that inhibition is an endophenotype of ADHD that holds an intermediate position in the causal pathway linking susceptibility genes to the overt manifestations of the disorder (Crosbie, Pérusse, Barr, & Schachar, 2008).

Social communication – or pragmatic language – is another domain that has been implicated in ADHD (Camarata & Gibson, 1999; Green, Johnson, & Bretherton, 2014). In contrast to inhibition, it has been suggested that pragmatic language deficits reflect downstream effects of the disorder that arise from underlying difficulties in inhibitory ability and other aspects of executive control (Bignell & Cain, 2007; Green et al., 2014; Nilsen & Fecica, 2011; Purvis & Tannock, 1997; Tannock & Schachar, 1996). Some of the pragmatic behaviours that have been associated with ADHD are embodied in diagnostic criteria for the disorder, such as difficulty attending when spoken to directly, interrupting others, and excessive talking (APA, 2000; Tannock & Schachar, 1996; Camarata & Gibson, 1999). Other pragmatic behaviours are not part of the diagnostic criteria per se but are commonly observed in school-aged children who have an ADHD diagnosis or who exhibit relatively high levels of ADHD traits. These findings are evident across both parent-report and performance-based tasks in which samples of the children’s communicative behaviour are measured. Examples include generating verbal output that contains more ambiguous sentences, less informative content, and that is poorly organized overall (Purvis & Tannock, 1997; Tannock, Purvis, & Schachar, 1993); making less use of context when interpreting figurative language (Bignell & Cain, 2007); having difficulty adapting to changing roles during communicative exchanges (e.g., between the roles of speaker and listener; Kim & Kaiser, 2000; Landau & Milich, 1988; Whalen, Henker, Collins, McAuliffe, & Vaux, 1979); making more errors when interpreting instructions provided by others (Nilsen, Mangal, & MacDonald, 2013); and exhibiting higher rates of inappropriate conversational behaviours – such as starting conversations inappropriately, using stereotyped language (e.g., changing topics suddenly, directing conversation toward personal interests), and engaging in less rapport building (e.g., failing to respond to questions or requests) (Bishop & Baird, 2001; Kim &

Kaiser, 2000). These behaviours have been observed even when ADHD children possess age-appropriate knowledge of pragmatic rules (Kim & Kaiser, 2000), which suggests that the social communication difficulties evidenced by children who have an ADHD diagnosis, or who exhibit relatively high levels of ADHD traits, may not be solely attributable to a pragmatic knowledge deficit – but rather may reflect difficulty with the application of existing knowledge in communicative contexts. Although comparatively little research has examined putative associations between pragmatic language and ADHD early in development, pragmatic language competence has been associated with inattention and hyperactivity in typically-developing preschoolers (Ketelaars, Cuperus, Jansonius, & Verhoeven, 2010), and with symptoms of impulsivity more specifically in young children with ADHD diagnoses (Geurts & Embrechts, 2008).

In summary, ADHD is associated with difficulties in several areas - including inhibitory ability and pragmatic language, which have been conceptualized as possible causes and consequences of the disorder, respectively. Given the role that pragmatic language deficits are presumed to play in the social impairment that often accompanies ADHD (Leonard, Lorch, & Milich, 2011), an important goal for research is to further elucidate the underpinnings of pragmatic language difficulties that are experienced by children who either have ADHD or evidence high levels of ADHD symptoms. To this end, we selected inhibitory ability for inclusion in our study because we believe it may be one of several mechanisms that underlie the inattentive and hyperactive-impulsive traits that define ADHD and associated difficulties in pragmatic language skill. Because research has primarily been conducted with school-aged children who have received an ADHD diagnosis, however, the extent that these constructs show evidence of mediation early in normative development is unknown. As such, this study was

undertaken to examine whether ADHD traits mediate the association of inhibitory ability and pragmatic language in typically-developing preschool-aged children. We focused our study on typically-developing preschoolers for several reasons: preschool-aged children show large individual differences in ADHD traits, which are manifest and normative early in development (Lakes et al., 2012; Palfrey, Levine, Walker, & Sullivan, 1985), young children are less likely to have co-morbid conditions that may compromise the development of their social communication skills (Bignell & Cain, 2007), inhibition and pragmatic language undergo rapid changes during the preschool period (McAuley, Christ, & White, 2011; O’Neill, 2007), and focusing on typical development enables us to extend findings that have largely been derived from clinical samples to the general population. Consistent with current thinking regarding the causes and consequences of ADHD (e.g., Crosbie et al., 2008; Green et al., 2014), we hypothesized that inattentive and hyperactive-impulsive traits would mediate the relationship between inhibitory ability and pragmatic language. Based on the suggestion that social communication difficulties in ADHD children may reflect a dissociation between the application and acquisition of pragmatic knowledge (Kim & Kaiser, 2000), we further hypothesized that mediation would occur when children were required to demonstrate the appropriate use of pragmatic rules rather than their familiarity with these rules per se.

## **2.1 Method**

### *Participants*

Fifty-three children aged 36 to 47 months were recruited from a university-affiliated early childhood education centre and from a database of community participants in the Department of Psychology at the University of Waterloo. Parents provided information regarding their children’s general health, developmental history, and language in a brief questionnaire developed

by the investigators. Following recruitment, all children were invited to participate in a set of tasks during an individual testing session with the researcher. Children's expressive and receptive language was screened using Body Part Naming and Identification from A Developmental Neuropsychological Assessment (NEPSY-II; Korkman, Kirk, & Kemp, 2007). Five children declined to participate in the individual testing session, and an additional four children declined to complete two or more of the tasks, and thus were not included in our analyses. An additional eight children were excluded from the study based on (1) suspected or diagnosed speech, hearing, or major health difficulties that would impact participation in the study, (2) less than one year exposure to English or minimal exposure to English on a daily basis, or (3) low performance (i.e., <10<sup>th</sup> percentile) on the language screening measure. The resulting sample (n = 36) consisted of 20 females (55.6%) and 16 males (44.4%), who ranged in age from 36 to 50 months ( $M = 43.12$ ,  $SD = 3.69$ ) at the time of testing. None of the children had diagnosed or suspected attention or behavioural concerns per parent report. Thirty-three of the 36 children (91.7%) spoke English as their first language and 20 (55.6%) were not exposed to any additional languages. Most participants were Caucasian, reflecting the composition of our surrounding community, and came from families in which parents generally reported having a college or university degree, which is somewhat higher than our community average based on available census data (Statistics Canada, 2014).

### *Materials*

*Strengths and Weaknesses of ADHD-symptoms and Normal-behavior (SWAN) rating scale.* The SWAN rating scale (Swanson, n.d.) is a parent or teacher questionnaire of traits associated with ADHD. Inattentive and hyperactive-impulsive dimensions are each represented by 9 items reflecting diagnostic criteria outlined in the Diagnostic and Statistical Manual of

Mental Disorders (4th ed., text rev.; DSM-IV-TR; APA, 2000). For each item, children are scored on a seven-point scale ranging from Far Below Average (+3) to Far Above Average (-3), such that ratings of Far Below Average indicate higher levels of inattentive and hyperactive-impulsive behaviour relative to their same age peers. Total scores reflecting inattention and hyperactivity-impulsivity were the focus of our study (possible range = +27 to -27). Cronbach's  $\alpha$  for these subscales are .91 and .93, respectively (Lakes et al., 2012).

*Statue.* The Statue subscale of the NEPSY-II assesses motor persistence and inhibitory control in children aged 3 to 6 years (Korkman et al., 2007). In this task, children are asked to maintain a still and silent position (i.e., like a statue holding a flag with their eyes closed) despite a number of distractions being purposefully introduced by the researcher during a 75-second period (e.g., knocking on the table). Successful completion of this task requires the child to inhibit impulsive responding to the distractors. The number of errors reflecting bodily movements, eye openings, and vocalizations were examined in our study (possible range = 0 to 15). Test-retest reliability estimates are .82 for 3 and 4-year old children from the normative sample (Korkman et al., 2007).

*Pragmatic Judgment.* Pragmatic rule knowledge was assessed using the Pragmatic Judgment subtest of the Comprehensive Assessment of Spoken Language (CASL; Carrow-Woolfolk, 1999). This task, appropriate for use with 3- to 21-year-olds, consists of 60 orally administered and increasingly difficult items which require children to formulate and provide appropriate pragmatic responses to a variety of hypothetical social scenarios (e.g., being polite in conversation, seeking and providing accurate information, appropriately commenting on upsetting situations). Responses generally receive a score of 0 (incorrect) or 1 (correct) based on their pragmatic appropriateness, irrespective of the grammar or structure of the response.

Administration began with the first item and was discontinued after 5 consecutive incorrect answers. The total number of points achieved across the administered items was examined in our study (possible range = 0 to 68, but note that pre-school aged children would meet the discontinuation criterion well before this upper limit). Rasch split-half reliability is .79 for 3-year-olds from the normative sample (Carrow-Woolfolk, 1999).

*Language Use Inventory for Young Children (LUI)*. Pragmatic rule application was assessed using the LUI (O'Neill, 2009). The LUI is a parent questionnaire that measures how children 18 to 47 months use their language in everyday situations or during communicative acts with others (i.e., pragmatic language). The questionnaire contains 180 items, most in a "yes/no" format, which make up 14 subscales. Part 3 of the measure consists of nine subscales assessing children's use of longer sentences in social communication (e.g., adapting conversations to the needs of others, telling coherent narratives, asking questions and making comments about themselves and others, using language to regulate others' activities). Total raw scores on Part 3 were the focus of our study (possible range = 0 to 133). Parts 1 and 2 were not included because children in our age range either no longer show the behaviours that are assessed by these questions or perform at ceiling (O'Neill, 2007). Cronbach's  $\alpha$  for Part 3 is .99 for the normative sample (O'Neill, 2009).

### *Procedure*

Parents of children recruited through the early childhood education centre were given envelopes containing information about the study, consent forms, parent-filled questionnaires, and a \$5 gift card. Parents of children recruited through the community database were contacted via telephone or email and completed the required forms during their visit to the self-contained, child-friendly testing room at the university. Once parental consent was obtained, children were

invited to participate in the individual testing session and were informed that they could decline to participate or cease participating at any time. Sessions were approximately 20 minutes in length. Parents who wished to be present were given the option of observing through a one-way window or sitting quietly in a discrete area of the room where the research was taking place. Parents were reminded of the importance of not prompting their children during the tasks, and were asked to withhold feedback until the end of the testing. Tasks were administered according to the directions outlined in their respective administration manuals and were presented to children in the following order: Body Part Naming and Identification, Statue, Pragmatic Judgment. All testing was conducted by a graduate student experienced in working with young children who was blind to responses on the parent-completed questionnaires. At the end of the session, children were presented with certificates of participation and a small gift (e.g., stickers).

## **2.2 Results**

Complete data were available for 32 participants (4 children declined to participate in the Statue task). Available data for all 36 participants were used to derive path values for the direct and indirect effects. The more conservative significance test for the indirect effect was then obtained from the dataset comprised of the 32 participants for whom complete data was available.

Descriptive statistics for variables that were entered into the analyses, and their correlations with age and gender, are presented in Table 1. Of note, there were no statistical outliers on any of the measures (i.e., scores outside 3 standard deviations of the sample mean) and almost none of the children had scores that would be considered “at risk” per recommended clinical cut-offs (e.g., Swanson et al., 2012) or comparisons with the normative sample (i.e., percentile scores below the 10<sup>th</sup> percentile). As shown in Table 1, gender was not significantly associated with any of the measures ( $p > .10$ ); however, age was negatively associated with body movement errors ( $r = -$

.40,  $p < .05$ ) and positively associated with pragmatic language scores on the LUI and CASL ( $r_s = .47$  and  $.46$ ,  $ps < .01$ , respectively).<sup>1</sup> As such, children's age at the time of testing was controlled in the mediation models. As per the recommendations of Hayes and Scharkow (2013), bias-corrected bootstrap tests of mediation were conducted using AMOS graphics software Version 21.0 (Arbuckle, 2012). This approach provides a more powerful test of indirect effects compared with other approaches in small samples (see also Woody, 2011). The models tested whether ADHD traits mediated the relationship between body movement errors from the Statue subtest of the NEPSY-II and pragmatic language. Body movement errors were selected as our index of inhibitory ability because of the infrequent occurrence of either eye opening or vocalization errors by participants.<sup>2</sup>

[Insert Tables 1 and 2]

Associations between inhibitory ability, inattention, and pragmatic language are depicted in Figure 1, with separate models presented for each pragmatic language outcome. There was a

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<sup>1</sup> As shown in Table 2, statistically significant bivariate correlations were observed between several of the key study constructs, including ADHD traits and the LUI (inattention:  $r = -.40$ ; hyperactivity-impulsivity:  $r = -.49$ ), hyperactivity-impulsivity and body movement errors ( $r = -.38$ ), and body movement errors and pragmatic language (LUI:  $r = -.38$ ; CASL:  $r = -.57$ ). *Note.* These correlational analyses, including Table 2, did not appear in the published manuscript.

<sup>2</sup> Separate models also tested whether ADHD traits mediated the relationship between total errors (i.e., body movement, eye opening, and vocalization errors) from the Statue subtest of the NEPSY-II and pragmatic language. The same overall pattern of results was unchanged, although some effects failed to reach significance.

significant negative direct effect of inhibition on the CASL, such that children who made more body movement errors also demonstrated worse pragmatic judgment. In addition, there was a significant negative direct effect of inattention on the LUI, such that children who were rated as more inattentive were also described as engaging in less appropriate pragmatic behaviours by their parents. There were no other significant direct effects in either model ( $p > .10$ ).

Furthermore, in neither model was the indirect effect of inhibition on pragmatic language significant ( $p > .10$ ).

[Figure 1]

Associations between inhibitory ability, hyperactivity-impulsivity, and pragmatic language are depicted in Figure 2. In both models, there was a significant positive direct effect of inhibition on hyperactivity-impulsivity, such that children who made more body movement errors were reported to be more hyperactive and impulsive by their parents. In addition, as previously reported, there was a significant negative direct effect of inhibition on the CASL. In contrast to the models above, there was a significant indirect effect of inhibition on pragmatic language depending on the outcome measure that was examined. More specifically, although there was no direct effect of inhibition on the LUI, there was a statistically significant indirect effect that was mediated by hyperactivity-impulsivity (standardized indirect effect:  $-.15, p < .05$ ). There was no evidence of mediation with respect to the CASL (standardized indirect effect:  $.06, p > .10$ ). These results show that children who made more body movement errors were rated as more hyperactive and impulsive by their parents and these children, in turn, were described by their parents as engaging in less appropriate pragmatic behaviours. The significant indirect effect suggests that inhibitory control predicts the application of pragmatic language through its effect

on hyperactive-impulsive behaviour, which in turn may interfere with a child's ability to effectively apply their pragmatic knowledge.

[Insert Figure 2]

### **2.3 Discussion**

ADHD is a clinically heterogeneous disorder that is frequently associated with impairments in other domains of function. Case in point, one recent study reported that 82% of school-aged youth with ADHD experience communicative impairments relative to 3.6% of typically-developing youth (Helland, Biringer, Helland, & Heimann, 2012). This is consistent with other work suggesting that some aspects of the communicative impairments may be as common in ADHD as they are in disorders defined by deficits in pragmatic language (e.g., the autistic spectrum; Geurts & Embrechts, 2008). Given the high prevalence of communicative impairments in youth with ADHD, research has sought not only to describe the specific nature of pragmatic difficulties associated with ADHD symptoms, but also to isolate potential causal factors which may account for this association. Despite growing theoretical interest in the potential contribution of executive functions, and inhibitory control more specifically, to the communicative impairments that have been observed in ADHD (e.g., Geurts, Broeders, & Nieuwland, 2010; Green et al., 2014), the extent to which ADHD traits, pragmatic language, and inhibitory ability may be associated is still somewhat speculative. With few exceptions (e.g., Huang-Pollock, Mikami, Pfiffner, & McBurnett, 2009), little empirical work has explored associations amongst these factors simultaneously in the context of a single study – and, to our knowledge, no studies have tested the stronger claim that ADHD traits may in fact mediate an association between inhibition and social communication. As such, this study was undertaken to examine the role of inhibition vis-à-vis the pragmatic language difficulties that have been

associated with ADHD traits in a non-clinical sample of preschool-aged children whose pragmatic language and inhibitory abilities are in a period of rapid development.

Consistent with our hypotheses, we found that hyperactive-impulsive traits mediated an association between inhibitory control and the application – though not knowledge – of pragmatic rules in young children. Our results provide a speculative explanation of why an underlying deficit in inhibitory control is predictive of poorer application of pragmatic language. Children who lack the ability to stop highly prepotent though inappropriate behaviours are more likely to have difficulty awaiting their turn, inhibiting urges to interrupt or intrude on the activities of others, and/or behaving in ways that are not in accordance with their own immediate desires. These hyperactive-impulsive traits may then interfere with learning how to behave appropriately in communicative settings – by, for example, making it difficult for such children to maintain a topic of conversation that is not of immediate interest or to engage in appropriate turn-taking during communicative exchanges. This suggests that while children with inhibitory deficits are more likely to experience pragmatic weaknesses, this may be especially so for those children who also demonstrate hyperactive and impulsive behaviours. Our study is an important first step in identifying hyperactive-impulsive traits as a mediator of the relationship between inhibition and pragmatic language in young children and, though we offer some suggestions regarding why hyperactive-impulsive behaviours may play this mediating role, these suggestions require further exploration in future research. Future research should also seek to understand other factors which may influence the proposed pattern of association, and more specifically, to explore if and why the pragmatic language of some children with inhibitory control difficulties is relatively unaffected (i.e., to identify factors which may protect against communicative impairments in children with poorer inhibitory ability).

Contrary to our expectations, inattentive symptoms did not emerge as a significant mediator of the relationship between inhibition and pragmatic language – even though we did find that children who displayed more inattention also showed more poorly developed pragmatic behaviours in their everyday lives (as per parent-report). Although it has been reported that pragmatic language may be more strongly associated with inattentive traits in school-aged children (Bignell & Cain, 2007), other work suggests that hyperactivity-impulsivity may be a better predictor of pragmatic competence earlier in development (Geurts & Embrechts, 2008). These seemingly discrepant findings may reflect the different trajectories along which ADHD traits emerge, with hyperactive-impulsive behaviours tending to manifest during the pre-school years and inattentive behaviours becoming more apparent upon the transition to formal schooling (Nolan, Gadow, & Sprafkin, 2001). Consequently, we believe that our pattern of results may be attributable to the age range of participants in our study, and that inattention might emerge as a significant mediator of the relationship between inhibitory ability and pragmatic language in older children. Extending our age range to include school-aged children would permit exploration of age as a potential moderator of the mediation we observed, which is another avenue for future research.

Consistent with expectations, our analyses revealed that children with poorly developed inhibitory ability evidenced deficits across both measures of pragmatic language. Indeed, previous research has found inhibition to be the only executive skill, after controlling for age, associated with children's performance in the role of a listener on a communicative task (e.g., Nilsen & Graham, 2009). It may be that inhibition allows for individuals to suppress initial notions for a communicative response in order to provide one which is more pragmatically-appropriate. As was predicted, however, the precise nature of the relationship between inhibitory

ability, ADHD traits, and pragmatic language varied depending on how the latter was examined. We differentiated between children's knowledge of pragmatic rules, as reflected in children's ability to formulate and provide pragmatically-appropriate responses to hypothetical social situations in a child-administered task, and their ability to apply pragmatic rules effectively in more authentic social situations, as reflected in parental ratings of children's communicative behaviours in everyday life. Interestingly, only with respect to the latter did hyperactivity-impulsivity emerge as a significant mediator. This suggests that inhibitory ability affects both facets of pragmatic language in communicative settings, but that hyperactivity-impulsivity is implicated more specifically in the appropriate use of pragmatic rules in social contexts.

Our results are consistent with previous work showing that children with high levels of ADHD traits possess age-appropriate knowledge of pragmatic language rules but experience difficulty with regards to the application of this knowledge in real-world situations. For example, Kim and Kaiser (2000) presented school-aged children with ADHD and age-matched controls a standardized task in which they were asked to provide responses to hypothetical social situations that were depicted in short narratives. Although the two groups demonstrated equivalent levels of pragmatic knowledge on the task, children with ADHD produced significantly more inappropriate communicative behaviours than control children during a subsequent free-play session with an adult conversational partner (e.g., failing to respond to questions and requests, interrupting others' speech). The results of our study provide further evidence that the social communication difficulties associated with ADHD traits arise from the inconsistent application of pragmatic knowledge in actual social contexts rather than a knowledge deficit per se, which may have important functional implications. Indeed, the inability to use language appropriately in social contexts may prevent children with ADHD traits from engaging successfully with

others (Leonard, Milich, & Lorch, 2011). ADHD traits may prevent children from effectively engaging in (and thereby, learning from) their social environments, which may, in turn, exacerbate any existing pragmatic impairments and social skills deficits.

Beyond elucidating the central role of hyperactive-impulsive traits in understanding the relationship between inhibitory ability and social communication early in development, this study has important implications for theoretical work aimed at specifying the precise way in which these factors are inter-connected. Our results support a model in which inhibitory control has a direct impact on pragmatic knowledge acquisition and an indirect impact on the application of pragmatic knowledge via hyperactive-impulsive behaviours. In this way, the mediation models put forward in our study conceptualize inhibitory control and social communication as antecedents to and consequences of hyperactivity and impulsivity, respectively. These models are consistent with current theoretical views identifying inhibitory difficulties as an etiological risk factor for ADHD and problems with social communication as a common downstream consequence of the disorder (Crosbie et al., 2008; Green et al., 2014). Because our models were tested in the context of a cross-sectional design, however, longitudinal exploration of inhibitory ability, ADHD traits, and pragmatic language would permit explicit testing of causal ordering.

This study contributes to our understanding of the pragmatic language difficulties that are commonly implicated in ADHD by highlighting inhibitory ability and hyperactive-impulsive traits as key predictors of emergent social communication in young children. Nevertheless, our conclusions should be interpreted in the context of several considerations. One consideration is that our study placed an intentionally narrow focus on just one aspect of executive functioning – that being inhibition. Inhibition is arguably the aspect of executive functioning that has shown the most robust association with ADHD (Lipszyc & Schachar, 2010), it has been identified as a

likely causal factor in the development of the disorder (Crosbie et al., 2008), it has been implicated in children's performance on communicative tasks (Nilsen & Graham, 2009), and it can be measured using psychometrically sound tools in very young children (Floyd & Kirby, 2001). Although inhibition was a logical candidate for inclusion in our study, particularly given the necessity of streamlining our battery of tasks to be suitable for use with preschoolers, the executive collective includes other skills that may also be relevant to this line of research. For example, the ability to mentally maintain goal-relevant information (i.e., working memory; Baddeley, 1992) has been associated with ADHD (e.g., Martinussen, Hayden, Hogg-Johnson, & Tannock, 2005) and pragmatic language (e.g., McInnes, Humphries, Hogg-Johnson, & Tannock, 2003), and is featured in theoretical accounts of successful social communication (Nilsen & Fecica, 2011). Thus, working memory is another aspect of executive functioning that should be considered for inclusion in future studies. A second, though related consideration, is that our battery of tasks included a single measure of each construct in order to minimize boredom and fatigue for our young participants. Because all measures contain some degree of error, however, a recommended practice is to administer multiple measures of a construct in order to examine relationships at a latent (rather than manifest) level (e.g., Cole & Preacher, 2013). This kind of latent variables approach presents some clear challenges for work involving preschool-aged children, but may be well-suited for future studies of older, school-aged participants. A third consideration relates to our assessment of pragmatic language and the extent to which our findings generalize to other measures. Given the breadth of behaviours encompassed within the domain of pragmatics, any measure of pragmatics, including the measures included in this study, will be necessarily limited. For example, our measures did not provide comprehensive assessments of nonverbal aspects of communication. Examining the extent to which these

findings hold for other measures of social communication will allow for a more precise understanding of the nature of pragmatic deficits that are associated with ADHD. Finally, our results should be interpreted within the context of the characteristics of children in our sample. Nearly all of our children were Caucasian and came from families in which parents had completed at least some post-secondary education, the latter of which may be associated aspects of language development (e.g., Dollaghan et al., 1999). Furthermore, while it is noteworthy that the observed pattern of associations emerged amongst our variables, despite this being a typically-developing sample in which low levels of concern were endorsed or observed across measures, it will be important for future studies to explore the extent to which these findings are generalizable to samples of impaired children.

In sum, our study constitutes an important step in further elucidating the precise way in which inhibitory ability, ADHD traits, and social communication are inter-related during development. We believe that broadening the scope of our work to include other executive skills and more precise measures of pragmatic language using a latent variables framework are important avenues for future research, as are expanding our age range of children and following them prospectively over time. By enhancing our understanding of the nature and causes of the pragmatic deficits experienced by children with symptoms of ADHD early in development, we may be better able to identify and implement appropriate interventions in order to circumvent the potentially negative social outcomes for those with communicative impairments later in life.

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Figure 1. The mediational role of symptoms of inattention. *Note.* Coefficients are standardized estimates. These results control for age of participants at the time of testing. \* $p < .05$ . \*\* $p < .01$ .

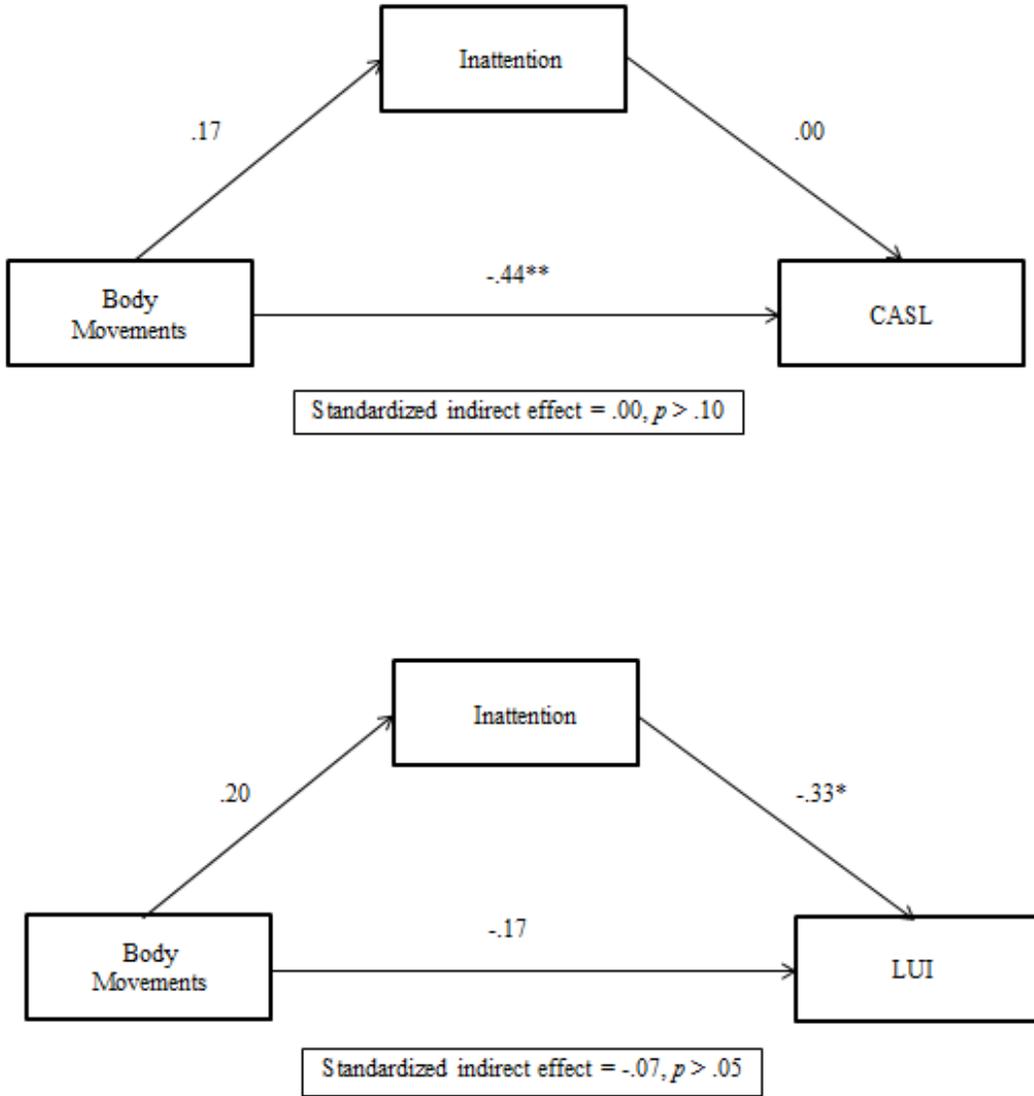


Figure 2. The mediational role of symptoms of hyperactivity-impulsivity. Note. Coefficients are standardized estimates. These results control for age of participants at the time of testing. \* $p < .05$ . \*\* $p < .01$ .

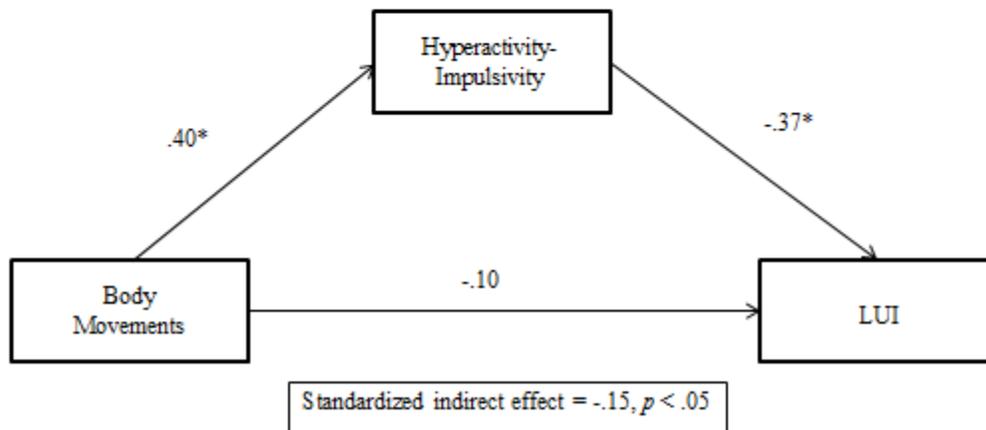
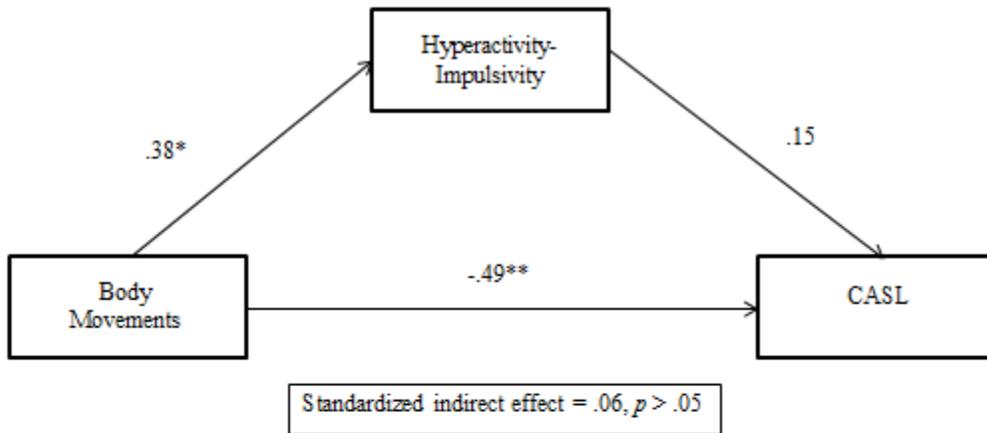


Table 1

*Means, Standard Deviations, and Correlations with Age and Sex of Participants for Measures of ADHD Traits, Inhibitory Control, and Pragmatic Language*

Measure	<i>M</i>	<i>SD</i>	<i>r</i> <sub>Age</sub>	<i>r</i> <sub>pbSex</sub>
ADHD Traits				
Inattention	-6.03	4.97	-.11	.25
Hyperactivity-Impulsivity	-4.08	6.00	-.24	.08
Inhibitory Control				
Body Movements	6.13	3.87	-.40*	.05
Eye Openings	3.28	3.65	-.06	-.09
Vocalizations	.94	2.06	-.19	-.25
Pragmatic Language				
LUI Part 3	123.14	7.20	.47**	.01
CASL	11.00	4.77	.46**	-.07

*Note.* Total raw score taken as index of performance on all tasks. Inattention = score on items measuring inattentive symptoms (SWAN rating scale); Hyperactivity-Impulsivity = score on items measuring hyperactive-impulsive symptoms (SWAN rating scale); Body Movements = total number of body movement errors (Statue); Eye Openings = total number of eye openings made (Statue); Vocalizations = total number of vocalizations made (Statue); LUI = score on Language Use Inventory Part 3; CASL = score on Comprehensive Assessment of Spoken Language Pragmatic Judgment subscale.

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

Table 2

*Bivariate Correlations amongst Key Study Variables*

Measure	1	2	3	4	5	6	7
1. ADHD Traits – Inattention	–						
2. ADHD Traits – Hyperactivity-Impulsivity	.69**	–					
3. Inhibitory Control – Body Movements	.20	.43*	–				
4. Inhibitory Control – Eye Openings	.12	.08	.51**	–			
5. Inhibitory Control - Vocalizations	.03	.13	.44*	.63**	–		
6. Pragmatic Language – LUI Part 3	-.40*	-.49**	-.38*	.03	-.02	–	
7. Pragmatic Language - CASL	-.12	-.13	-.57**	-.32	-.14	.40*	–

*Note.* Total raw score taken as index of performance on all tasks. Inattention = score on items measuring inattentive symptoms (SWAN rating scale); Hyperactivity-Impulsivity = score on items measuring hyperactive-impulsive symptoms (SWAN rating scale); Body Movements = total number of body movement errors (Statue); Eye Openings = total number of eye openings made (Statue);

Vocalizations = total number of vocalizations made (Statue); LUI = score on Language Use Inventory Part 3; CASL = score on Comprehensive Assessment of Spoken Language Pragmatic Judgment subscale.

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