

Learning to cooperate: The impact of executive functioning, theory of mind and externalizing behaviours on children's social functioning

by

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### Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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## Abstract

Developing the ability to interact in a socially competent manner (i.e., in which one's own needs and goals are met and the needs and goals of others are considered) is a complex process that is likely influenced by one's cognitive skills, as well as other individual characteristics. This dissertation sought to examine the unique contributions of children's executive functioning, theory of mind and verbal skills on their socially appropriate behaviours and how these relationships change at different ages. The interaction effect of executive functions and symptoms of Attention-Deficit/Hyperactivity Disorder (ADHD) and Oppositional Defiant Disorder/Conduct Disorder (ODD/CD) on social behaviour, while controlling for the other symptoms profile, was also investigated. Younger (5-8 years old) and older (9-12 years old) children's everyday social skills and symptoms of ADHD and ODD/CD were assessed using parent-report questionnaires. Children completed tasks to assess their executive functioning (i.e., inhibitory control, working memory, and planning skills), theory of mind, and verbal skills, and participated in an interactive dyadic cooperative task to assess their social behaviours with peers. Because children participated in pairs, dyadic data analysis was used to examine the effect of individual characteristics on children's own and their partners' social behaviours. Results indicated that theory of mind was related to younger children's, and their partners', social skill; however, planning, theory of mind, and verbal skills were related to older children's and/or their partners' social behaviours. Furthermore, executive functions interacted with symptoms of ADHD to affect older children's, and their partners', social skills, even when controlling for symptoms of ODD/CD. These findings suggest that children utilize different cognitive skills at various developmental stages in order to guide their social behaviours. In addition, executive functions appear to moderate the effect of symptoms of ADHD on children's and their partners'

socially competent behaviours. Findings have implications for theories of children's social development, as well as for intervention strategies aimed at enhancing the social skills of youth.

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## Dedication

This Dissertation Thesis is dedicated to my Olivia, who inspires me to be the best I can be, and to my husband Jeremy, whose encouragement, patience, support and unwavering faith in me contributed to this accomplishment.

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## **Introduction**

The social environment is an integral part of people's lives; thus, it is vital that children learn to function within their social contexts. For children to become socially competent they must develop the ability to interact with other social partners in an effective manner, meaning that they can meet their own needs and goals while simultaneously considering the needs and goals of others. Such a task requires recognition of the intentions of others, as well as the cognitive skills to use this information to modify one's behaviour accordingly, all the while being mindful of the situational context in which the interaction takes place. Because social interactions are a fundamental and pervasive aspect of human lives, it is important to ascertain how social competence develops and identify the factors that promote and support its development. This dissertation investigated younger and older school-age children's abilities to modify and regulate their social behaviours, disruptive behaviours that may hinder these abilities, and the cognitive skills that facilitate socially competent behaviour. The present work also examined the reciprocal nature of social interactions, that is, the way in which each child affects the behaviour of the other. For example, a child who is interacting with a more socially competent partner may consequently demonstrate more socially appropriate behaviours. Dyadic data analysis was used to investigate the effect of children's characteristics (e.g., cognitive skills) on their social partners' behaviours. Furthermore, the relation between children's cognitive skills and their own social behaviours was examined while controlling for the effect of their partners' cognitive skills and behaviour.

### **Defining Social Competence**

An important starting point is the clarification of the definition of social competence in order to establish common ground across research in this area (Rose-Krasnor, 1997). Social

competence is largely conceptualized in the research literature as being able to adapt effectively within a social environment (Ciairano, Visu-Petra, & Settanni, 2007; Green & Rechis, 2006; Rose-Krasnor). This involves being able to take on the complex task of interacting appropriately with others in different contexts wherein one is able to meet one's own needs and goals and consider the needs of others (Green & Rechis; Rose-Krasnor).

Even though this general definition of social competence is established in the research literature, there remains no clear consensus on what constitutes the key elements of social competence. In order to provide greater understanding in the field Rose-Krasnor (1997) proposed a theoretical framework for defining socially competent behaviours, in which social competence is seen as an organizing construct that involves various characteristics. First, socially competent behaviours include *transactional* characteristics that involve a joint product of the individual, social environment, and other social actors. Second, there are *context-dependent* characteristics where effective behaviours need to be adjusted according to different contexts. Third, there are *performance-oriented* characteristics that involve the ability to appropriately utilize a skill in conditions that may not be ideal (e.g., stressful) and may require emotion regulation abilities. Finally, there are *goal-specific* characteristics that involve being able to select strategies that will be effective for the specific situation and being able to perform certain behaviours that will help one accomplish specific goals. In sum, social competence involves constantly keeping in mind and updating information from the (social) environment in order to effectively utilize and coordinate one's own abilities in the face of environmental demands and balance one's own needs with the needs of others (Rose-Krasnor; Green & Rechis, 2006).

Within the broader social environment children will encounter many different types of social contexts. Specific to the current study there are cooperative contexts, in which one's goal

is convergent or shared with another individual. Social competence in a cooperative context would thus involve appreciating the shared goal and choosing to follow a strategy that involves combining efforts with another to more effectively reach that goal (Brownell & Carriger, 1990; Tomasello, 2007). This type of context contrasts with competitive contexts in which one has divergent goals with another social actor and chooses to follow a strategy that involves reaching one's own individual goal in opposition to another's goal.

### **Development of Social Competence in Cooperative Contexts**

Being able to cooperate with others reflects an important and fundamental component of social behaviour (LaFreniere, 1996). The ability to collaborate with other social actors develops rapidly over the first few years of life with the support of children's growing cognitive abilities. Specifically, by the end of their first year children demonstrate some of the social cognitive skills involved in working cooperatively with others (e.g., understanding the intentional actions of others, coordinating attention with another person and an object of shared interest, gesturing to communicate and share experiences) and by 14-months-old children show a basic understanding of collaborative goals (Henderson & Woodward, 2011; Tomasello, 2007; Tomasello & Carpenter, 2007). Throughout their second year, children begin to cooperate and share more with others; all the while they are developing some important social cognitive skills (e.g., understanding and differentiating self versus others; being able to represent specific causal relations between one's own actions and the independent actions of one's partner; Brownell & Carriger, 1991; 1990; Hay, 1979). However, even by the middle of their second year children continue to have difficulty joining their own efforts with another social actor. Such a task would involve some important cognitive processes that would aid in the monitoring and control of thought and action, such as executive functions (EFs). Executive functions begin to flourish in

the preschool to early school years (Carlson, 2005; Riggs, Jahromi, Razza, Dilworth-Bart, & Mueller, 2006). In line with this development, by the end of the second year, children are able to coordinate their behaviour with a peer to achieve a common goal (Brownell & Carriger, 1991; Warneken, Chen, & Tomasello, 2006). For example, Brownell and Carriger (1990) found that children of this age were able to coordinate their own behaviours with another child in order to manipulate an apparatus to achieve a shared goal (e.g., getting a toy). By the preschool years, children are engaging in more prosocial behaviours where they display direct helping or sharing behaviours with others (e.g., sharing or directing another to share a limited resource or a toy; Cook & Stingle, 1974; Olson & Spelke, 2008; Smiley, 2001). Through the preschool to school age years (3-5 years-old) children display a developmental progression of engaging in a more, “well-adjusted, flexible, emotionally mature, and generally prosocial pattern of social adaptation” (LaFreniere & Dumas, 1996, p. 373).

### **Cognitive Skills Involved in Social Competence**

As described above, behaving in a socially competent manner is a complex process that requires the coordination of many skills, such as *attending to* and using cues within the environment, identifying one’s own goals and the goals of others, coordinating one’s own behaviour accordingly, and flexibly applying strategies to different situational contexts. It stands to reason that behaving in a socially competent manner would require a complex set of cognitive skills, including the ability to think about the intentions of others and the ability to use this information to guide one’s own behaviour.

**Theory of mind and social competence.** There is general consensus in the literature that ‘theory of mind,’ the ability to attribute and understand the mental states of others (e.g., desires, feelings, thoughts and beliefs), is essential to everyday social interactions (Hughes,

Fujisawa, Ensor, Lecce, & Marfleet, 2006; Hughes & Leekam, 2004). Theory of mind (ToM) allows one to attribute independent mental states to others and use information about others' intentions, desires, thoughts, and beliefs to make sense of the social world—that is, to interpret and predict the actions of others and to guide our behaviours in these situations (Ashiabi, 2007; Bosacki & Astington, 1999; Decety, Jackson, Sommerville, Chaminade, & Meltzoff, 2004). In fact, Bosacki and Astington found that the ToM skills of sixth grade children, measured using brief social vignettes and questions to assess social understanding, were positively related to peer and teacher ratings of their social competence. In a longitudinal study, Razza and Blair (2009) found that early false-belief understanding (ToM) in preschoolers predicted later social competence in kindergarten. Furthermore, Dunn and Cutting (1999) found that preschool children's ToM skills (i.e., an aggregate score of seven ToM tasks and a deception task), affective perspective-taking skills, and emotion understanding were correlated with their cooperative pretend-play turns with another child. The authors also found that children who performed more poorly on ToM and affective perspective-taking demonstrated more conflict behaviour with the other child. Moreover, there are well-established deficits in the ToM abilities of children diagnosed with Autism Spectrum Disorder, a disorder with impairments in social reciprocity and communication (Tager-Flusberg, 2007). In conclusion, ToM appears to play a vital role in guiding socially competent behaviour.

**Executive functions and social competence.** In addition to appreciating the mental states of others, EFs have been shown in the research literature to be important in guiding individuals' social interactions and in promoting social-emotional competence (Decety et al., 2004; Nigg, Quamma, Greenberg, & Kusche, 1999; Riggs et al., 2006). One must not only understand the thoughts and intentions of others, but also be able to use this information to guide

and regulate one's own behaviours. Executive functioning (EF) is generally referred to as higher-order, self-regulatory cognitive processes that facilitate goal-directed behaviour by enabling the maintenance of behaviour on a goal set and calibration of behaviour to a context (Carlson, 2005; Pennington & Ozonoff, 1996; Hughes, 1998). Executive functioning is typically thought to be comprised of components including inhibitory control, cognitive flexibility, working memory and planning (Blair, Zelazo, & Greenberg, 2005; Diamond, 2006; Garon, Bryson, & Smith, 2008). It should be noted that there is debate in the literature over whether EF is a unitary construct or can be separated into these component processes (Garon et al., 2008); however, research does seem to indicate that, in individuals 6 years of age and older, the most common EF components are inhibition of prepotent responses, mental set shifting (or cognitive flexibility), and working memory (Lehto, Juujarvi, Kooistra, & Pulkkinen, 2003; Miyake et al., 2000). Planning is also viewed in the research literature as a higher-level EF, critical to goal-oriented behaviour (Best, Miller, & Jones, 2009; Miyake et al., 2000).

Particularly relevant to the present research are inhibitory control, working memory and planning ability. Inhibitory control (IC) involves the ability to suppress or withhold a prepotent thought or response (e.g., involving interference control, cognitive inhibition and/or motor response inhibition; Ciairano et al., 2007; Friedman & Miyake, 2004; Nigg, 2000). Working memory (WM) involves the ability to hold information in mind and to mentally manipulate that information (Baddeley, 2012; Davidson, Amso, Anderson, & Diamond, 2006). Finally, planning involves the ability to look ahead to the attainment of a future goal, to anticipate consequences of one course of action on another, to plan actions in advance, to approach a task in an organized, strategic, and efficient manner and to monitor goal attainment (Best et al., 2009; Oosterlaan, Scheres, & Sergeant, 2005).

There are systematic, age-related improvements in EF that occur during young childhood and continue through into adolescence. Research shows that EF skills can emerge as early as infancy and become more refined throughout the preschool and school years (Diamond, 2006). The different components of EF show evidence of maturing and going through periods of most rapid change at different ages (Best et al., 2009). Inhibitory control shows marked improvements during the preschool period (3- 5 years old; Diamond, 2006). For example, on a Go/No-go task where children are instructed to respond to specific stimulus (“go”) and to inhibit responding to another stimuli (“no-go”), children 3-4 years old can correctly state these instructions but are not able to inhibit responding to the no-go stimulus (i.e., errors of commission; Best et al., 2009). However, around 4.5 years old, children begin to curb errors of commission to the no-go stimulus and improvements continue to be seen between 5-8 years old, especially when the task becomes even more difficult requiring more rapid responding or when the ratio of go to no-go responses is increased (Best et al., 2009; Diamond, 2006).

The development of working memory shows evidence of a unique and longer developmental trajectory than inhibitory control (Huizinga, Dolan, & van der Molen, 2006; Huizinga & Van der Molen, 2007). During the school years (5- to 11 years old), children show gradual and increased improvements on working memory tasks, including both auditory or spatial working memory tasks (Best et al., 2009). Because performance on working memory tasks also depends on task difficulty, improvements in working memory continue to be seen into adolescence (e.g., 15 years old; Best et al., 2009; Diamond, 2006). For example, Huizinga and colleagues (2006; 2007) found that performance on working memory tasks continued to develop into young-adulthood, whereas performance on inhibition tasks reached adult-levels by adolescence.

Planning ability is perhaps the pinnacle of EF, in that it may be the last component to develop and is built on previous EF components (Best et al., 2009). This ability increases with age and, like working memory tasks, adult levels of performance also depend on task difficulty. With more complex planning tasks, this skill seems to develop most rapidly at some point in late childhood and adolescence (Best et al., 2009). For example, Huizinga and colleagues (2006) found that planning abilities (i.e., the number of additional moves, planning time, and the number of perfect solutions on a Tower of London task) continued to develop into adolescence and sometimes into young-adulthood.

Despite a plethora of research in this area, research on typical EF development has disproportionately focused on investigating the age during the preschool years when specific components of EF emerge, neglecting their later developmental course towards complete maturation (Best et al., 2009). Consequently, there is a need to assess EF in school-age children, particularly because the relations among EF components may change as children establish new skills. For example, a study by Isquith, Gioia, and Espy (2004) found that EF components are less differentiated for younger children than for older children. As well, children of different ages may coordinate the different components of EF in different ways and find different aspects of EF challenging when carrying out goal-directed behaviour. For instance, Huizinga and Van der Molen (2007) found that in younger children (7-year-olds), performance on the Wisconsin Card Sorting Task was predicted by performance on tasks assessing shifting and inhibition abilities; whereas, performance for older children (11 years old and older) was predicted by performance on tasks assessing shifting and working memory abilities, but not inhibition. This suggests that younger children (7-year-olds) relied more on inhibition skills in order to perform successfully on the Wisconsin Card Sorting Task; whereas, older children (11-year-olds and older) relied

more on working memory abilities. It seems that younger children may rely more on IC than older children, because IC develops earlier than other EFs; however, once IC is established other developing EFs may play a more important role in guiding behaviour (e.g., WM and eventually planning; Best et al., 2009). For example, relations among planning and other EF components change with age. In younger children (younger than 4 years old) IC predicts planning performance (i.e., on the Tower of Hanoi task); however, in older children (4-6 years old) WM predicts planning performance (Senn, Espy, & Kaufmann, 2004).

By studying a broader age range, it may be revealed that the relations between EFs and solving complex problems in everyday life (e.g., navigating successfully through one's social environment) vary with age. Because components of EF become established at different times, children of varying ages may recruit different EF components to navigate these experiences. Knowledge of which EF skills are recruited during successful completion of complex problem solving in social situations and how this changes with age is important not only for theoretical reasons, but also for practical ones, such as developing interventions for school children with poor social skills and EFs (Best et al., 2009).

**Relations between executive functions and social competence.** Several studies have investigated the relations between EF and social competence. These studies reveal that children's EF abilities relate to appropriate and effective behaviours and strategies within various social contexts. For instance, in a two year longitudinal study, Nigg and colleagues (1999) measured children's (aged 6-8 years old) neuropsychological functioning (i.e., verbal fluency, inhibitory control, and visual spatial ability) and how this was related to teacher ratings of children's social competence. They also measured more general cognitive abilities (i.e., IQ and reading ability) in order to control for these variables. Results demonstrated that measures of inhibitory control

predicted later social adjustment, as rated by teachers, while controlling for the other cognitive variables. Another longitudinal study investigated the relation between inhibitory control and social competence, in particular cooperative behaviours (Cairano et al., 2007). At the first time point, children from three age groups (7-, 9-, and 11-year-olds initially) completed a Stroop task to measure their inhibitory control and then played a jigsaw puzzle with a partner for a limited time period. One year later, the same children again completed the Stroop task and the puzzle task. The authors found that, at both time points, dyads who performed worse on the Stroop task at Time 1 (i.e., both individuals demonstrated weaker inhibitory control) concurrently displayed significantly fewer cooperative behaviours during the Jigsaw puzzle task (e.g., giving a puzzle piece to their partner to use) than dyads who demonstrated better inhibition skills. Furthermore, inhibitory control at Time 1 was found to be the most influential stable predictor of non-cooperative behaviours at Time 2 during the puzzle task. Another study investigated the effects of traumatic brain injury (TBI) on EF and social competence in children 3 years 0 months to 6 years 11 months (Ganesalingam, Yeates, Taylor, Walz, & Wade, 2012). At 6 months post-injury, EFs were assessed using neuropsychological tests, and social competence was assessed using parent ratings. It was found that parent ratings of EFs accounted for significant variance in measures of social competence. However, these results may also be attributed to method variance, as the neuropsychological tests (in contrast to parent-ratings of EFs) were not significant predictors. A recent study by McQuade and colleagues (2013) examined the relation between working memory and social functioning. Nine to 12-year-old children completed measures of working memory (i.e., verbal and spatial working memory) and were rated by teachers on different aspects of their social functioning (i.e., peer rejection, overall social competence, and physical and relational aggression, and conflict resolution skills). It was found

that a composite of working memory ability was significantly related to all aspects of social functioning as assessed by teachers. Finally, Bonino and Cattelino (1999) investigated the relation between cognitive flexibility and cooperative relations with peers. Seven-year-old boys and girls completed the Wisconsin Card Sorting Task in order to measure their cognitive flexibility. These children were then paired according to sex and similar level of flexibility in order to complete a cooperative tied-pencils task. In order to be successful at this collaborative task, children had to negotiate and cooperate with each other in order to coordinate their two crayons (tied together by a short piece of string) to colour a picture. It was found that child pairs with high levels of cognitive flexibility had significantly more cooperative interactions and turn-taking than child pairs with low levels of cognitive flexibility. Bonino and Cattelino suggest that flexibility in thinking allowed children to find “a new cognitive representation of the task and of the mutual role of self and partner” and be able “to restructure the social situation and the task and find an effective way to complete the task not in competition, but in co-operation” (p. 32). It is important to note that children with higher levels of EF abilities may influence the behaviours of children with lower levels and vice versa, thus it is important to control for the mutual influence that social partners may have on each other (Kenny, Kashy, & Cook, 2006). In a recent study, Huyder & Nilsen (2012) used dyadic data analysis to control for the mutual influence that occurs between two social partners. In this study, children (6- to 8-year-olds) with more proficient inhibitory control (i.e., assessed on the Simon Says task where they had to inhibit certain responses according to the examiner’s instructions) demonstrated fewer competitive behaviours during a cooperative task (i.e., a puzzle game). This effect was found even when controlling for children’s other cognitive skills (i.e., cognitive flexibility, ToM and verbal skills), as well as their partner’s cognitive skills (i.e., inhibitory control, cognitive flexibility, ToM, and

verbal skills). An important strength of this study was the use of dyadic data analysis to account for the reciprocity and influence between interacting social partners. Furthermore, this study and two others mentioned previously (i.e., Bonino & Cattelino; Ciairano et al.) provide a measurement of social competence within an ecological setting and a problem-solving scenario, allowing the direct observation of children's social behaviours and comparison of such behaviours across the same situation (Green & Rechis, 2006). Unfortunately, these studies have not used a broad age range when assessing the relations between the different EF components (e.g., IC, WM and planning) and social competence. Consequently, it is unclear whether these specific EF components, which come on line at different ages, play differential roles in socially competent behaviour at various ages.

### **The Importance of Social Competence in Development**

The development of children's social competence and the cognitive skills that influence its development has become a well-researched topic in the developmental literature due to the strong influences social competence has on later life adjustment (Ciairano et al., 2007; Bonino & Cattelino, 1999). For example, social competence is important in how one gets along with peers and forms relationships (Ashiabi, 2007). Furthermore, longitudinal evidence suggests a link between poor social adjustment in childhood and later life difficulties, such as early school drop-out, juvenile and adult criminality, later internalizing and externalizing problems, and adult psychopathology (Hymel, Rubin, Rowden, & LeMare, 1990; Parker & Asher, 1987). In addition, social competence is important in children's socio-emotional development, which in turn has been found to play an important role in many aspects of children's development, such as school readiness and academic performance (Ashiabi; Wentzel & Asher, 1995). Halberstadt and colleagues (2001) also state that children's abilities to express and interpret their own emotions

and the emotions of others has an impact on how successful their strategies are during social interactions. Thus, the development of social competence and social-emotional development appear to have mutual influences on each other and in turn affect other important areas of children's development.

### **Externalizing Behaviours and Social Functioning**

There are two childhood disorders that are of particular relevance to the present study, Attention Deficit Hyperactivity Disorder (ADHD) and Oppositional Defiant Disorder (ODD)/Conduct Disorder (CD). Attention Deficit Hyperactivity Disorder (ADHD) is a behavioural disorder, affecting approximately 5% of school-age children, which is characterized by a persistent and developmentally inappropriate pattern of inattention and/or hyperactivity-impulsivity (American Psychiatric Association, 2013). Oppositional Defiant Disorder (ODD) is a behavioural disorder, affecting on average about 3% of school-age children, characterized by a persistent pattern of negativistic, hostile and defiant behaviour (American Psychiatric Association). More extreme, Conduct Disorder (CD) is a behavioural disorder, affecting between 2-10% of school-age children, characterized by a repetitive and persistent pattern of behaviour in which the basic rights of others or major rules of society are violated (American Psychiatric Association). ODD and CD are highly related and ODD is shown to predict CD, thus they are hereafter referred together as ODD/CD (Clark, Prior, & Kinsella, 2002).

Both ADHD and ODD/CD are associated with marked impairments in social functioning. Several studies have found social impairments in populations of children with a diagnosis, or elevated symptoms, of ADHD. For instance, a study by Charman and colleagues (2001) demonstrated that children with ADHD were rated significantly lower by parents on the socialization domain of an adaptive functioning survey. Furthermore, children who were rated as

more hyperactive by parents were found to have more conflicts with friends and engaged less frequently in joint pretend play with their friends (Dunn & Cutting, 1999). Diamantopoulou and colleagues (2007) also found that symptoms of ADHD negatively predicted children's peer nominations of a "Social Preference Score" and prosocial behaviour, and positively predicted peer nominations of physical and relational aggression. Furthermore, children with ADHD are less likely to change their behaviour to fit role expectations when compared to non-ADHD controls (Landau & Milich, 1988) and in a computerized chat-room task, children with ADHD made more off-topic, hostile responses (Mikami, Huang-Pollock, Pfiffner, McBurnett, & Hangai, 2007). Kolko and Pardini (2010) also found that children with ADHD continued to demonstrate social problems with peers even after psychosocial interventions, suggesting that social skills training may need to be expanded to help these youth respond less impulsively in social situations. In sum, children with ADHD are described as having fewer friends, as showing consistently aggressive, dysregulated and unskilled social interactions, as tending to play with others much younger than themselves and as being frequently nominated by classmates as least-liked (Ohan & Johnston, 2007; Ronk, Hund, & Landau, 2011).

ODD/CD and ADHD are highly comorbid externalizing disorders and, while both are associated with social deficits, they appear to have a few distinct differences. For instance, when compared to typically-developing controls, boys with ODD/CD and ODD/CD + ADHD selected aggressive responses in social problem-solving situations more often, selected a prosocial response less often and were more confident they could be aggressive; however, this difference, relative to a typically-developing peer group, was not found in a purely ADHD group (Matthys, Cuperus, & Van Engeland, 1999). ODD has also been found to be associated with increased hostility towards peers and decreased respect for adults, in comparison to ADHD and control

groups, as rated by parent and teachers on questionnaires of children's social behaviours (Frankel & Feinberg, 2002). Furthermore, on a computer game, girls with combined ADHD + ODD were seen as more overtly and relationally aggressive and less prosocial, compared to girls with ADHD only, who in turn were seen as more overtly and relationally aggressive and less prosocial than control girls (Ohan & Johnston, 2007).

### **Executive Functioning and Social Competence in Relation to ADHD and ODD/CD**

Although some studies control for the comorbidity between ADHD and ODD/CD, it is at times unclear what is unique to each disorder and whether they are clinically distinct disorders. Of key interest in the present study, is the role EF skills play in ADHD versus ODD/CD and how EF skills relate to the social deficits observed in both these disorders.

**Executive functioning in ADHD and ODD/CD.** Studies seem to generally indicate that deficits in EF are more strongly related to ADHD than to ODD/CD. In regards to ADHD, a meta-analytic review by Willcutt and colleagues (2005) suggested that the strongest and most consistent EF deficits in ADHD were obtained on measures of response inhibition, vigilance, working memory and planning. It is fairly well-established that there are response inhibition deficits related to ADHD (Berlin & Bohlin, 2002; Berlin, Bohlin, & Rydell, 2003; Brocki, Nyberg, Thorell, & Bohlin, 2007; Brocki, Randall, Bohlin, & Kerns, 2008; Charman, Carroll, & Sturge, 2001; Geurts, Verte, Oosterlaan, Roeyers, & Sergeant, 2005; Oosterlaan, Logan, Sergeant, 1998; Sergeant, Geurts, Oosterlaan, 2002; Thorell & Wahlstedt, 2006; Tillman, Thorell, Brocki & Bohlin, 2008; Verte, Geurts, Roeyers, Oosterlaan, & Sergeant, 2006). There also seems to be strong evidence for WM deficits in ADHD, although the evidence is a bit mixed. For example, several studies found WM deficits, especially visuospatial WM deficits, that are specifically related to ADHD-hyperactive or inattentive subtypes (e.g., Brocki et al.,

2008; Thorell & Wahlstedt, 2006; Kalff et al., 2002; Martinussen, Hayden, Hogg-Johnson, & Tannock, 2005; Oosterlaan et al., 2005). Of note, many of these studies included children with a diagnosis of ADHD or children high on symptoms of ADHD and the ages of children varied widely, from 4 years old to adolescence. On the other hand, a few studies did not find a relationship between WM deficits and ADHD (Brocki et al., 2007; Geurts et al., 2005). Brocki and colleagues (2007) recruited 72 children (mean age=5 years, 5 months; 1/3 of which were identified as being at high risk for developing diagnosable ADHD and/or ODD) and tested them at Time 1 using 7 different tasks of EF, including a test of spatial WM and verbal WM. At Time 1 and Time 2 (approximately 2 years later), parents and teachers completed a questionnaire containing items from the DSM-IV criteria for ADHD and ODD. Results revealed no relation between performance on the two types of WM tasks and symptoms of ADHD or ODD at Time 1 or Time 2. Similarly, Geurts and colleagues (2005) compared 16 boys with ADHD-Inattentive subtype (I), 16 boys with ADHD-Combined subtype (C) and 16 typically-developing control boys (6-13 years old) on five major domains of EF, including visual WM. There were no significant differences between the three groups on the visual WM task. It is unclear why these two studies found no relations or differences between WM and ADHD status or symptoms of ADHD. This could be due, in part, to the use of different tasks to measure WM, to smaller sample sizes, or to lack of control for ADHD versus ODD/CD symptoms.

Recent research has not found response inhibition or WM deficits in relation to ODD/CD, when partialing out or controlling for hyperactivity or ADHD (Berlin & Bohlin, 2002; Brocki et al., 2007; Kalff et al., 2002; Oosterlaan et al., 2005; Sergeant et al., 2002; Thorell & Wahlstedt, 2006). A less recent review of the literature by Sergeant, Geurts and Oosterlaan (2002) shows less executive dysfunction for ODD/CD, but still some deficits in IC. However, it is unclear

whether this deficit is found because of the presence of ADHD symptoms; thus, it is important to “control for the presence of comorbid ADHD symptoms in CD children using statistical techniques” (Sergeant et al., 2002, p. 22).

Finally, planning deficits seem to be related specifically to ADHD, although the evidence is again a bit mixed. For example, planning deficits (i.e., on the Tower of Hanoi task) were found specifically for children (7- to 13.5-year-olds) diagnosed with ADHD-combined type, but not for children diagnosed with ADHD-inattentive type (Klorman et al., 1999). Interestingly, children in this study diagnosed with ODD-only performed significantly better than children without ODD on the Tower of Hanoi task. In addition, a study with school-age children (7-13 years old) found that planning deficits (i.e., on the Tower of London task) were significantly related to teacher-rated symptoms of ADHD; whereas, low errors on the Tower of London task were associated with increased parent-report of ODD/CD symptoms (Oosterlaan, Scheres, & Sergeant, 2005). On the other hand, Geurts and colleagues (2005) did not find deficits in planning abilities (i.e., on the Tower of London task) in an ADHD group compared to a typically developing group. An important difference in this study was that ODD/CD symptoms were not controlled for. As mentioned above in the previous two studies, this is important to control for because children with ODD have been shown to perform better on planning tasks (Klorman et al., 1999; Oosterlaan et al., 2005). In summary, it seems EF deficits may be more prominent in ADHD than in ODD/CD and, in fact, *better* planning abilities may be related specifically to ODD/CD.

**Relations between executive functioning and social competence in ADHD and ODD/CD.** The relation between EF and social competence appears to differ for children with ODD/CD versus ADHD; thus, EFs may help to explain the relationship between social deficits

and ADHD, but perhaps not ODD/CD. In a recent study examining EF and social competence in ADHD, EF explained the relationship between ADHD and some social behaviours (Huang-Pollock, Mikami, Pfiffner, & McBurnett, 2009). Specifically, 8- to 12-year-old children with ADHD-C, ADHD-I and non-ADHD controls completed measures of EF, which were combined into an overall EF score. Social competence was measured through parent and teacher ratings on social skills questionnaires and performance on a Chat Room task (i.e., a conversation between four children and the participant that is simulated by a computer). Results indicated that EF partly mediated the relation between ADHD status and the ability to detect subtle verbal cues and memory for conversation in the social chat room task. However, EF did not mediate the relationship between ADHD status and the number of prosocial, hostile or on-topic statements made. Interestingly, this study also found that EF did not explain the relationship between ADHD status and parent or teacher report of social adjustment. The authors suggest that this variability in their findings may be because parent and teacher ratings capture aspects of social adjustment that are less dependent on a child's EF skill. In another study, 6- to 10-year-old boys with a diagnosis of ADHD (excluding those with a comorbid diagnosis of CD) and 22 typically developing boys (8-to 10-year-olds) were compared (Charman et al., 2001). Again, it was found that parental ratings of social competence were not correlated with EF (i.e., performance on an inhibition task and a planning task) for the ADHD group and only planning abilities were related to social competence for the typically developing controls. Similarly, Biederman and colleagues (2004) found that EF deficits (i.e., impairment on two or more tasks from a battery of 6 EF tasks administered) were not related to children with ADHD's social functioning, as assessed by a structured interview with mothers. This is similar to the studies conducted by Huang-Pollock and colleagues and Charman and colleagues, where no relationship was found between EF and parent

and teacher ratings of social competence within an ADHD population. It is possible that these discrepant findings are due to different methodologies used to assess social competence (i.e., parent and teacher ratings versus observations of social behaviour in a laboratory task). On the other hand, Kofler and colleagues (2011) examined the relationship between working memory, a domain general “central executive” ADHD, and social problems. Children 8-12 years old with or without a diagnosis of ADHD completed measures of intelligence and working memory (i.e., phonological and visuospatial working memory, from which a central executive score was calculated). Parents and teachers completed measures to assess children’s social problems and symptoms of ADHD. Results indicated that ADHD symptoms mediated the relationship between the central executive and children’s reported social functioning. In a recent study by Bunford and colleagues (2014), the relationship between executive deficits, ADHD symptoms and social impairment was examined. Children from third to sixth grade completed measures of intelligence, inhibitory control, and working memory. Parents and teachers completed measures to assess children’s disruptive behaviour disorder symptoms (i.e., ADHD, ODD, CD) and social competence. It was found that symptoms of hyperactivity/impulsivity mediated the association between inhibitory control and teacher-rated social impairment; whereas, symptoms of inattention mediated the association between working memory and teacher-rated social impairment. It should be noted that this effect was only found when not controlling for the other symptom profile.

When looking at peer ratings, instead of parent or teacher ratings, of social competence, Diamantopoulou and colleagues (2007) found that EF interacts with ADHD symptoms to affect peer ratings of social competence. This longitudinal study used a community-based sample of children (8-8.5 years-old at Time 1 and 9.5 years-old at Time 2 to examine the combined effects

of ADHD symptoms (rated by parents and teachers on a scale based on the DSM-IV diagnostic criteria for ADHD) and EF (assessed using a IC task, a non-verbal WM task, a verbal WM task, and a verbal fluency task) in relation to social outcomes (i.e., peer nominations of social preference at Time 2) and academic outcomes (i.e., teacher ratings of academic performance at Time 2). Results indicated that low levels of EF deficit combined with low, as opposed to high, levels of ADHD symptoms were associated with higher peer nominations of prosocial behaviour; however, at high levels of EF deficit, prosocial behaviour did not differ as a function of levels of ADHD symptoms. These results indicate that EF skills interact with symptoms of ADHD to affect social behaviours.

Of note, in looking at the role that EF may play in problematic social behaviour in regards to ADHD and ODD/CD, no studies to date (to the author's knowledge) have differentiated between these two disorders (or controlled for symptoms of ADHD versus ODD/CD). For example, Fahie and Symons (2003) examined the social behaviour of a sample of children (5- to 9-year-olds) clinically referred for attention and behaviour problems; however ADHD and ODD symptoms were not distinguished. Social functioning for each participant was measured through parent and teacher ratings of social problems and general child behaviours. An aggregate score of EF was created using performance on EF tasks and parent and teacher ratings of attention problems and impulsivity. Results revealed that social problems and EF were significantly related, even when controlling for ToM, age, language and SES. Similarly, a study including adolescents (12-15 years old) with ADHD, ODD/CD, ADHD + ODD/CD and controls found that, across this sample, EF predicted parent-reported communication and socialization skills (Clark et al., 2002). Unfortunately, this study and the previous did not differentiate

between ADHD and ODD/CD; therefore, it is unclear what role EF plays in ADHD versus ODD/CD when looking at socially competent behaviours.

### **Present Investigation**

The research literature described above can be summarized in the following key ways. First, previous research reveals relations of children's ToM and EF skills with socially competent behaviours (e.g., Bosacki and Astington, 1999; Bonino and Cattelino, 1999, Ciairano et al., 2007, Nigg et al., 1999). As well, evidence suggests that EF components develop at different ages; thus, children of different ages may draw upon these components in distinct ways to solve complex problems (e.g., social interactions). Furthermore, children high on symptoms of ADHD and/or ODD/CD exhibit impairments in social functioning. However, EF deficits may be unique to ADHD and related to the social difficulties exhibited by children with ADHD, but may not be related to symptoms of ODD/CD and the social problems associated with ODD/CD.

This brings me to the goals of this dissertation research. The first aim was to examine the unique contributions of EF components, ToM, and verbal skills on social competence and determine whether different cognitive skills, particularly EF components, were related to social competence at different ages. It was important to include verbal skills in this study as research indicates that EF components, ToM and verbal skills are all interrelated and all have effects on social behaviours (e.g., Bosacki & Astington, 1999; Razza & Blair, 2009); thus, it is common practice to control for language ability when examining the relations between EF, ToM and social competence. In addition, I was interested in examining the unique contributions of EF and ToM to social competence. Some studies show a relation between EFs and ToM in which EF may be a facilitator of ToM understanding (Carlson & Moses, 2001; Carlson, Moses, & Breton, 2002; Carlson, Moses, & Claxton, 2004; Hughes 1998; Hughes & Ensor, 2007; Carlson, Mandell

& Williams, 2004; Nilsen & Graham, 2009). It may be that EFs support ToM skills or allow for the expression of ToM in a social context. Thus, it was expected that EF components would have unique effects on social behaviours while controlling for ToM and verbal skills. Furthermore, it was expected that the relations among EF components and social competence may change with age. Because EF components develop at different ages and children of different ages may coordinate components in distinct ways when carrying out goal-directed behaviour (e.g., a cooperative social task), the skills that may be drawn upon to solve complex problems may change over the course of development (Best et al., 2009). As well, as children move into their mid-school-age years, they enter a new set of experiences (e.g., the peer group becomes increasingly important at this age); thus, EF may play an especially important role in social functioning as children become older.

The second aim of this study was to determine whether there are individual differences in EF related specifically to ADHD symptoms in comparison to ODD/CD symptoms. There is mixed evidence regarding EF deficits in ADHD versus ODD/CD and whether children with ODD/CD have better planning abilities, although the majority of studies seem to indicate that EF deficits are more prominent in ADHD. Of interest was to examine the relation between ADHD symptoms and EF skills when controlling for ODD/CD symptoms and vice versa in order to establish what is unique to each behavioural profile. This study focused on symptoms of ADHD and ODD/CD in a “typically” developing population. To date, most studies examining EFs in relation to these disorders have focussed on comparing clinical samples to a control group; however, it is important to understand how these relationships operate along the continuum and when controlling for the other symptom profile (Sergeant et al., 2002). This is important to

study given these disorders likely operate along a continuum, rather than categorically, and will help extend findings to the general population.

The third aim of this study was to investigate whether EF components play a more prominent role in guiding socially competent behaviour in ADHD symptoms than ODD/CD symptoms and whether this changes with age. If there are specific EF deficits related to symptoms of ADHD but not ODD/CD and EF is related to social competence, then EF will moderate the relationship between symptoms of ADHD and social deficits, but not the relationship between symptoms of ODD/CD and social deficits. Specifically, it may be that at low levels of EF there is a relation between symptoms of ADHD and social behaviours; however, at high levels of EF there may be less of a relationship. On the other hand, one's level of EF skill may not interact with symptoms of ODD to affect social behaviour. Another question was whether different EF components moderate the relationship between ADHD symptoms and social deficits at different ages. As described above, EF components develop at different ages and may be recruited differently. These questions have important implications for treatment interventions for these two clinical groups and children of different ages.

The present dissertation research attempted to fill the gaps in the literature by addressing some limitations in past studies and building on previous work. First, because most research has investigated children's social competence using parent or teacher ratings, rather than also comparing children across a standardized social context, the present study used a task that allowed observation of children's behaviours in a standardized ecologically valid social setting where they were interacting with other children (i.e., one which children would often encounter in a school or play setting). To assess socially competent behaviours, children's social behaviours were measured in a cooperative context in which children were asked to work with

another child to complete a pattern of colours using wooden blocks. Furthermore, as children's behaviours were expected to affect each other in these social interactions, it was important to control for these dyadic relationships between social partners (i.e., how children affect their social partners' behaviours); thus, dyadic data analyses were used. As well, because the contradictory findings regarding the relation between EF and social competence in ADHD may be due in part to the use of different methodologies, the use of parent ratings of social competence was also included.

Second, because the measurement of cognitive skills in past studies on the relations between EF and social competence has had some limitations, the present study sought to assess different components of EF (i.e., inhibitory control, working memory, and planning). For instance, some studies used tasks that may not be valid measures of the component being assessed (e.g., the Stroop task may not be a valid measurement of inhibitory control in children; MacLeod, Dodd, Sheard, Wilson, & Bibi, 2003). As well, some studies used only one task to assess one component of EF; however, because EF has been found to be a multifaceted construct, it should be measured more comprehensively using other measures that assess the various components of EF (Miyake et al., 2000). This is especially important because different components of EF may be recruited in distinct ways by children of different ages in order to manage complex problems (e.g., social interactions; Best et al., 2009; McQuade et al., 2013). Consequently, the present study used various measures to assess different components of EF (i.e., inhibitory control, working memory, and planning).

Third, because of the interrelations between EF, ToM, and verbal skills, this study assessed and controlled for these different skills when looking at their relationships with social competence. Research suggests that ToM skills are related to the development of social

competence and that there are interrelations between EFs and ToM skills. As well, research indicates a relation between verbal ability, other cognitive skills, and social competence (Bosacki and Astington, 1999; Carlson & Moses; Dunn & Cutting, 1999; Jacques & Zelazo, 2005; Nigg et al., 1999). Due to these interrelations, this study sought to clarify the unique contributions of EFs, ToM, and verbal skills on social competence.

Finally, as research demonstrates specific EF deficits in ADHD compared to ODD/CD, and sometimes better planning abilities in ODD/CD, it was important to control for symptoms of ADHD and ODD/CD. This allowed for identifying what is unique to each symptom profile and what role EF plays in socially competent behaviours for those high in ADHD versus ODD/CD symptoms.

In sum, the present study included measures of EF, ToM, and verbal skills in order to investigate the unique contributions of each in facilitating socially competent behaviour, while also assessing for symptoms of ADHD and ODD/CD. Younger and older children's skills were assessed using three tasks that measure different factors of EF (i.e., inhibitory control, working memory, and planning). Children also completed tasks assessing their ToM and verbal skills. Parents completed measures to assess children's social skills and symptoms of ADHD and ODD/CD. By measuring these different components of EF, ToM, verbal skills, and symptoms of ADHD and ODD/CD in the same study, this study sought to fill the gap in the literature. Specifically, this allowed for the examination of the unique contributions made by EFs, ToM, and verbal skills to social competence, how these relationships may change with age, and how EFs are related to ADHD versus ODD/CD symptoms and interact with these symptoms to affect social behaviours.

## Method

### Participants

Two-hundred and sixty-two participants were recruited from Senior Kindergarten, Grade 1, 2, 4, 5 and 6 classes within schools from the Waterloo Region Catholic District School Board and the Waterloo Region District School Board. However, thirteen participants were removed from all analyses because they did not have a partner to complete the social task with ( $n = 6$ ) or they had a diagnosis of Autism Spectrum Disorder or Intellectual Disability ( $n = 5$ ). Because the study entailed dyadic relationships, if the child met the above criteria, both that child and his/her partner were removed. Two-hundred and forty-eight participants in total remained. Only children who had the written permission of their parents and verbal permission of their teacher participated in this study.

There were 130 children in the younger age group (69 males) and the ages ranged from 61.00 to 98.90 months of age ( $M = 79.66$ ,  $SD = 10.19$ ). There were 118 children in the older age group (52 males) and the ages ranged from 108.40 to 154.40 months of age ( $M = 126.46$ ,  $SD = 12.03$ ). Please see Tables 1 and 2 for additional demographic information (i.e., ethnicity and parent level of education) regarding the younger and older samples, respectively.

### Materials

**Social measure.** In order to measure children's on-line social behaviours, an interactive block game was used. This consisted of two 13'' X 13'' wooden frames, each consisting of a pattern of 100 1'' X 1'' coloured squares in which to fit 1'' X 1'' wooden blocks. There were 150 wooden blocks for children to choose from (15 blocks of each of the 10 colours on the wooden frames) (see Figure 1). There was also a 13'' X 13'' wooden frame model displaying a specific number of correctly placed wooden blocks to demonstrate the point system

for the children. A stopwatch was used to keep track of the 3 minute time limit within which children had to correctly place as many of the wooden blocks on the two wooden frames as they could. A whiteboard was used to record the team's total score when they finished.

**Parent measures.** Parents were given a questionnaire to gather demographic information about each child (see Appendix A). Furthermore, in order to assess symptoms of Oppositional Defiant Disorder (ODD) and Attention Deficit Hyperactivity Disorder (ADHD) in the domains of Hyperactivity/Impulsivity and Inattention, parents were asked to complete the SNAP-IV Teacher and Parent Rating Scale, a revision of the Swanson, Nolan and Pelham (SNAP) Questionnaire (Swanson et al., 1983). This is a 90-item questionnaire with a 4-point rating scale (0=Not at all to 4=Very much) on which parents choose the rating for each item that best describes their child. The SNAP-IV consists of items that can be summed to provide a total score for DSM-IV subtypes of ADHD (Inattention and Hyperactivity/Impulsivity) and ODD/CD. This measure has been shown to have high internal consistency (i.e., .94-.97 for parent and teacher ratings; Bussing, Fernandez, Harwood, Hou, Garvan, Eyberg, & Swanson, 2008). Finally, in order to assess children's social skills, according to parent ratings, parents completed selected items from the Strengths and Difficulties Questionnaire (SDQ). This is a 25-item screening instrument to evaluate behavioural and emotional concerns that can be separated into 5 scales: Emotional Symptoms, Conduct Problems, Hyperactivity; Peer Problems; and Prosocial Behaviour. Parents completed the 10 items that load onto the Peer Problems and Prosocial Behaviour scales. Items are rated on a 3-point scale with the choices being "not true", "somewhat true", and "certainly true." The SDQ has been used in the past as a measure of social competence or behavioural adjustment (Dunn & Cutting, 1999; Rydell, Thorell, & Bohlin,

2007). There is also initial support for adequate test-retest reliability (i.e., .85 for the Total Difficulties score) and concurrent validity of the SDQ (Kelley, Reitman, & Noell, 2003).

### **Procedure**

Parents of children enrolled in schools that participated in this research were sent information letters, consent forms and questionnaires to complete (if they consented to have their children participate) in order to gather some demographic and symptom information about each child. After children received consent from their parents to participate, in the school, children were assigned to pairs by randomly selecting their names from the class roster. Children were assigned to a partner of a similar age and, whenever possible, from the same classroom. Children participated in the study during the regular school day at a time designated by their teacher, and children were asked verbally whether they wanted to participate in the study.

Children first completed the interactive cooperative social task with their partner and then completed several tasks individually with a researcher (i.e., in two separate rooms) in the following order: inhibitory control task, working memory task, planning task, ToM task, verbal skills task. All tasks were always presented in this fixed order because we were interested in looking at individual differences amongst participants. A fixed order is standard practice when looking at individual differences because, “it is critical that the individuals be exposed to identical stimulus contexts. That context includes not only the stimuli themselves but also the order in which they are presented” (Carlson & Moses, 2001, p. 1035).

This in-school session took a total of approximately 50 minutes for each child.

### **Social Measure**

The interactive cooperative block game was used to measure children’s social behaviours and was designed to elicit a variety of behaviours from children (i.e., cooperative, competitive).

In order to investigate children's social skills in a cooperative context, pairs of children completed the block game as a team. Children were each presented with a wooden frame and instructed to correctly place as many of the coloured blocks as possible on their wooden frame (i.e., correctly match the colour of the block to the colour on the wooden frame) within the 3 minute time limit in order to earn the most points for their team. The two wooden frames were located immediately in front of each child in a pair. The wooden blocks were laid out face-down (the coloured side facing down), randomly placed behind the two wooden frames. Children sat beside each other, having been randomly assigned to sit in front of one of the frames (i.e., left or right side of the other child), and were instructed that it was their job to complete the wooden frame in front of them; however, children were also told that they were allowed to help each other with each other's wooden frames.

Before beginning the task, each pair was asked to choose a team name in order to highlight the collaborative nature of the task. This was then written on a scoreboard where the team's total score after completing the task was written. A partially completed wooden model was used to demonstrate the point system in which children would receive 1 point for each correctly placed block and 10 bonus points if they correctly placed all the blocks for one colour. Children were told that there were not enough blocks for both of them to complete all the colours on each of their wooden frames. This was done so that children would need to coordinate who would use which blocks to the best advantage of the team. Children were reminded that they needed to work together to earn the most points for their team and that they could earn the most points by completing as many colours of blocks as possible. Children were given one rule to follow: if they picked up a block they must put the piece back face down, unless they or their partner was actively using that piece to complete one of the wooden frames. This rule was to

ensure that children would have to make a decision with each block that they or their partner may need; they could either use the piece on their own frame or turn it back over and not help their partner or assist their partner by providing the block. The complete instructions for completing this task are presented in the Appendix B. During this task, children's behaviours were video recorded for later coding.

After completing this task, children were asked a series of questions to assess their understanding of the task (see Appendix C).

*Coding.* Children's cooperative, competitive and neutral behaviours, including both verbal and non-verbal behaviours, during the interactive cooperative social task were coded by a research assistant who was blind to the research hypotheses and to children's parent-reported behaviours. To ensure reliability in coding, a second research assistant coded the behaviours of 70 randomly chosen participants (25% of the total sample). The interrater reliability of the child's total number of behaviours, weighted as described below, was calculated for each of the three different types of behaviour: cooperative behaviour  $ICC(69) = .99, p < .01$ , competitive behaviour  $ICC(69) = .24, p = .13$ , and neutral behaviour  $ICC(69) = .99, p < .01$ .<sup>1</sup> Children's behaviours were coded as cooperative if they demonstrated behaviours intended to help or collaborate with their partner (i.e., actions that were focused on or would serve the team's shared

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<sup>1</sup> The interrater reliability for the competitive behaviours was recalculated by transforming this variable into a categorical variable and calculating Kappa's coefficient, which was still fairly low (Kappa = .35). It seems that the coders were disagreeing most on whether there was zero competitive versus one competitive behaviour. However, I also tallied the total number of times raters agreed versus disagreed on the number of competitive behaviours occurring for each participant (e.g., rater 1 coding participant A as having "zero" behaviour and rater 2 coding participant A as having "zero" behaviour would equal one tally for agreement; whereas, rater 1 coding participant B as having "one" behaviour and rater 2 coding participant B as having "two" behaviours would equal one tally for agreement and one tally for disagreement). Using this analysis, raters were found to agree on 61 occasions and disagree on 13 occasions across participants; therefore, they were agreeing 82% of the time. This is similar to their agreement for the cooperative behaviours (i.e., 90%). For this reason, I decided to proceed with analyses that included the coding for the competitive behaviours.

goal). For example, cooperative behaviours included actions such as giving the other child a block to put on his/her wooden frame, asking the other child if he/she needs help, or making cooperative statements (e.g., “We’re doing well!”). Children’s behaviours were coded as competitive if they demonstrated self-interested objectives or intentions to hinder the other child’s completion of his/her wooden frame (i.e., actions that were focused on self versus other or that would serve one’s individual goal). For example, competitive behaviours included picking up a coloured block that the other child said they needed and either using it on one’s own frame or putting it back face-down, verbal bragging about one’s own half in comparison to the other child’s (e.g., “I’m doing better than you!”), or negative comments about the other child’s progress (e.g., “You’re slow!”). A scoring system was employed in order to account for behaviours that demonstrated more direct helping or hindering (e.g., putting a block in the correct location on the other child’s half or picking up a block that the other child has explicitly indicated a need for and putting it on one’s own model). These types of behaviours were given 2 points, whereas less direct behaviours (e.g., making cooperative statements versus negative comments about the other child; planning who would work on which colours versus ignoring verbal advice from the other child and continuing with previous action) were given 1 point. Finally, behaviours were coded as neutral if they neither aided nor hindered the other child and did not fit under the cooperative or competitive categories (e.g., picking up a block that the other child does not want and putting it on one’s own model). Every relevant behaviour was counted separately, even when two or more different behaviours occurred simultaneously (e.g., a child making a verbal comment and a non-verbal behaviour at the same time). (See Appendix D for coding criteria).

Pilot testing was completed to ensure that the task was developmentally appropriate for both age groups. Results from this testing revealed that the block game elicited a wide range of social behaviours (i.e., cooperative and competitive behaviours), the instructions were understood by children, and the difficulty of the task and a time limit of 3 minutes was appropriate for both age groups.

### **Cognitive Measures**

**Inhibitory control.** A computerized version of the Go/No-go task was used as a measure of inhibitory response control (i.e., the number of commission errors on this task) and has been found to be appropriate for elementary-aged and older children (Araujo et al., 2009; Berlin et al., 2003, McAuley & White, 2011). This task is widely used to measure IC in research regarding ADHD and has been shown to have moderate reliability (e.g., Pearson product moment correlations between .56 and .70; Berlin & Bohlin, 2002; Kuntsi, Andreou, Ma, Borger, & van der Meere, 2005). In this task, children were seated in front of a computer screen on which they were presented with 1 of 4 shapes one at a time in a random order. Children were instructed to press the spacebar as fast as they could when 3 of these 4 shapes were presented (“go”); however, when the remaining 1 of these 4 shapes was presented (“no-go”) they were to withhold this response. The “no-go” shape was chosen at random by the computer program before a participant began. Participants were presented first with 20 practice trials, then with 4 blocks of 50 test trials each. This task measured children’s ability to refrain from performing certain actions/behavioural responses and their reaction times to responding. The ability to withhold a response on the “no-go” trial constituted the dependent measure for inhibitory control.

**Working memory.** The Finger Windows subtest from the Wide Range Assessment of Memory and Learning Second Edition (WRAML2; Sheslow & Adams, 2003) was used as a measure of children's spatial working memory. This subtest is appropriate for a wide age range (5-90 years old) and has been shown to have a reliability estimate of .91 (Sheslow & Adams). The backward administration of this task was used and has been used in past research as a measure of spatial working memory (e.g., Manassis, Tannock, Young & Francis-John, 2007; Murray, Childress, Giblin, Williamson, Armstrong, & Starr, 2011). This is a standardized test and was administered according to standardized procedures, except that children were told to imitate the same sequence in the reverse order instead of the same order. In this task, the researcher indicated a series of spatial locations by inserting a pencil through a series of randomly spaced holes ("windows") on an 8 X 11 inch card at a rate of one hole per second. The child was then required to reproduce the same visual-spatial sequence in backward order by putting his/her finger through the hole in the reverse order of that presented by the researcher. Items presented by the researcher gradually increased in length from 2 hole sequences to 6 hole sequences. In this task, children began testing at the age appropriate start point (i.e., Item 1 for 8 year olds and younger; Item 4 for 9 year olds and older). Testing discontinued after 3 consecutive scores of 0, and a maximum of 27 points could be earned. Raw scores were used in analyses.

**Planning.** The Tower subtest from the Developmental Neuropsychological Assessment (NEPSY; Korkman, Kirk, & Kemp, 1998), designed to be appropriate for ages 5-12 years old, was used to assess children's nonverbal planning abilities. This standardized test has been shown to have reliability estimates between .72 and .90 for this age range and was administered according to standardized procedures (Korkman et al.). In this task, children were

instructed to replicate different patterns of cylinders using three balls on three pegs in as few moves as possible. Children were also told to follow three rules: 1) Only one ball may be moved at a time; 2) A ball may not be placed on the table or in the lap or be held in one hand while moving a ball with the other hand; and 3) A move cannot be changed once the child has taken his or her hand off the ball. All children began at item 3. This task was discontinued after 4 consecutive scores of 0, and a maximum of 20 points could be earned. Raw scores were used in analyses.<sup>2</sup>

**Verbal skills.** The Listening Comprehension subtest from the Wechsler Individual Achievement Test – Third Edition (WIAT-III; Wechsler, 2009) was administered as an assessment of children’s verbal skills. This subtest is appropriate for individuals aged 4-50 years old and has been shown to have reliability estimates between .67 and .73 for children in my age range (Breux & Frey, 2010). This test was administered according to standardized procedures. Specifically, children were shown four pictures on one page at a time and asked to point to the picture that showed the word spoken by the researcher. Items were scored incorrect (0 points) if the picture pointed to or the answer chosen did not match the word said by the researcher. All children began at item 1. This task was discontinued after 4 consecutive scores of 0, and a maximum of 19 points could be earned. Raw scores were used in analyses.

**Theory of mind.** The Theory of Mind subtest from the NEPSY-II was used to measure children’s abilities to understand mental functions (e.g., belief, intention and deception) and another’s point of view (Korkman, Kirk, & Kemp, 2007). This is a standardized test with

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<sup>2</sup> It should be noted that for 19 participants, this task was administered incorrectly (i.e., the researcher allowed children to restart an item, if requested); however, the scores for these children were corrected accordingly and these children’s corrected scores ( $M = 11.89$ ,  $SD = 2.02$ ) did not differ from the scores of 19 other randomly chosen participants of similar ages in our sample who were administered the task correctly ( $M = 11.79$ ,  $SD = 2.44$ ),  $t(36) = -0.15$ ,  $p > .05$ .

reliability estimates between .76 and .84 and was administered according to standardized procedures (Korkman et al.). The Theory of Mind subtest of the NEPSY-II consists of two tasks; however, only the first task, the Verbal Task, was used. This task entails children being read various scenarios or being shown pictures and then being asked questions that, to be successfully answered, require knowledge of another's point of view. In this task, children began testing at the age appropriate start point (i.e., Item 1 for 5-6 year olds; Item 4 for 7-8 year olds; and Item 6 for 9-16 year olds). Testing discontinued after 4 consecutive scores of 0, and a maximum of 22 points could be earned. Raw scores were used in analyses.

## Results

### Overview

Recall that the first aim of this study was to determine the unique contributions of EF components, ToM, and verbal skills on socially competent behaviour and whether different cognitive skills (e.g., EF components) are related to social competence at different ages. Specifically, it was expected that the relations among EF components and social competence would change with age. The second aim of this study was to investigate whether EF is related to symptoms of ADHD or ODD/CD while controlling for the other symptom profile. Finally, this study explored whether EF components moderate the relationship between symptoms of ADHD or ODD/CD and social skills and how these relationships change with age.

Before addressing the primary research questions, children's performance on the predictor variables (inhibitory control, working memory, planning, theory of mind skills, and verbal skills) and the relations between these variables was examined. Next, children's scores on the parent ratings of children's social skills were examined. Finally, children's performance on the cooperative social task and the relations between each child's own behaviours and his/her partner's behaviours were analyzed.

Following these initial analyses, and to answer the first research goal (exploring the relations between cognitive skills and social competence at different ages), children's cognitive skills were examined in relation to their social skills, as rated by parents. These relationships were then compared between the older and younger age groups. Next, children's cognitive skills were examined in relation to their behaviour during the cooperative social task. Because children completed the social task with another child in a dyadic relationship where social partners could influence each other's thoughts, emotions, and behaviours, the main analyses were conducted using the Actor-Partner Interdependence Model. This model allows one to investigate both actor

effects (i.e., when an individual's score on a predictor variable affects that same individual's score on an outcome variable) and partner effects (i.e., when an individual's score on a predictor variable affects his/her partner's score on an outcome variable). Thus, I was able to investigate the interdependence between the members of each dyad when addressing my main hypotheses. Furthermore, a multiple-sample SEM was applied to these models in order to test whether the effects of cognitive skills on social behaviours changed between the younger and older groups.

Before addressing the second research goal (examining relations between ADHD/ODD and EF), children's scores on the parent ratings of children's ADHD and ODD/CD symptoms were examined (i.e., the means and standard deviations). To answer the second research question, the correlations between children's executive functioning skills and ADHD or ODD/CD symptoms were examined, while controlling for the other symptom profile.

Finally, in order to answer the third research question, the effect of the interaction of children's executive functioning skills with symptoms of ADHD or ODD/CD on children's parent-reported social skills was examined using SEM. Furthermore, the effect of the interaction of children's executive functioning skills with symptoms of ADHD and ODD/CD on children's behaviours during the cooperative social task was examined using the Actor-Partner Interdependence Model. Finally, a multiple-sample SEM was applied to these models in order to test whether the interaction effects on social skills changed between the younger and older groups.

### **Initial Analyses**

A MANOVA with gender as the grouping variable was conducted for the younger and older age groups on the cognitive variables, the social task behaviours, and the parent ratings of social skills. For the younger group, there were no significant effects of gender on any of the

cognitive measures,  $F(4,125) = 2.30, p > .05$ , nor on any of the social task behaviours,  $F(2,127) = 0.69, p > .05$ ; however, there was a significant effect of gender on the parent ratings of social skills,  $F(2,118) = 7.35, p < .01$ . For the older group, there were no significant effects of gender on any of the cognitive measures,  $F(4,113) = 1.11, p > .05$ , nor on any of the social task behaviours,  $F(2,113) = 0.43, p > .05$ , nor on any of the parent ratings of social skills,  $F(2,114) = 2.87, p > .05$ . Because gender did not significantly affect the predictor variables, as well as most of the dependent variables, gender was not included in further analyses for either age group.

**Cognitive tasks.** Children's performance on the cognitive tasks (i.e., Go/No-Go, Finger Windows, Tower, ToM, and verbal task) is presented in Table 3 for the younger and older groups. As in previous studies (e.g., McAuley & White, 2011), a measure of inhibitory control from the Go/No-Go task was computed by dividing the number of incorrect responses on a no-go trial by the total number of no-go trials (i.e., the no-go false alarm rate, where a higher score on this variable means worse inhibitory control). Individual scores on this variable that exceeded 3 standard deviations above the overall mean were removed from further analyses ( $n = 1$  for the younger group;  $n = 2$  for the older group). All measures showed good variability, with no floor or ceiling effects, which suggests that the tasks used were age-appropriate for the younger and older samples.

The relations between the children's demographic and cognitive skills were examined (see Table 4 for the younger group and Table 5 for the older group). Specifically, bivariate correlations between the children's performance on the No-Go false alarm rate, Finger Windows, Tower, ToM, Vocabulary and age were calculated. Similar to previous research, analyses revealed significant interrelations between the predictor variables and age, particularly for the younger group (Carlson & Moses, 2001; Carlson, Moses, & Breton, 2002; Carlson, Moses, &

Claxton, 2004; Hughes & Ensor, 2007). Specifically, all cognitive variables, except the No-Go false alarm rate, and age were interrelated for the younger age group. On the other hand, for the older group only the Finger Windows, ToM and Vocabulary were interrelated and only the Tower, ToM, and Vocabulary were significantly related to age. As such, age (within group) was controlled for in the main analyses investigating the effects of cognitive skills on social behaviours.

**Parent ratings of social skill.** Children's general social abilities were assessed by having parents complete the Prosocial and Peer Problems scales from the Strengths and Difficulties Questionnaire. Because I sought to combine these two scales to create a total social skill measure, these scales were scored so that a higher score on the Prosocial scale meant more prosocial behaviour; whereas, a higher score on the Peer Problems scale meant less peer problematic behaviour. These two scales were significantly related for the younger group,  $r = .24, p < .01$ , and the older group,  $r = .32, p < .01$ ; and were combined to create an overall Total Social skill measure, where a higher score reflected greater social competence. Children's scores are presented in Table 6 for the younger and older groups. Cronbach's alphas for the Total Social skill score was .62 for the younger group and .72 for the older group. Note that only the Total Social skill measure was included in the main analyses.

**Cooperative social task.** To gather more objective information about children's on-line social skills, children's cooperative, competitive and neutral behaviours were recorded and coded from the cooperative social task. The two main variables of interest were the cooperative and competitive behaviours and only these behaviours were included in the main analyses; however, neutral behaviours were also coded in order to account for the varying number of behaviours each child was performing during the task that were neither cooperative nor

competitive (i.e., they neither aided nor hindered the social partner). In a sense, the neutral behaviours would account for children's mere speed at completing actions during this task (e.g., finding and putting a block in place). In order to account for these neutral behaviours, proportions were calculated. That is, the proportion of cooperative behaviours was calculated by dividing the total number of cooperative behaviours by the total number of cooperative, competitive and neutral behaviours. The same proportion was calculated for the competitive and neutral behaviours. Table 7 displays the mean and standard deviations for children's overall number of behaviours and proportion of behaviours for the younger and older groups. It should be noted that the competitive behaviours occurred quite infrequently in the older group and that both cooperative and competitive behaviours occurred infrequently in the younger group, suggesting that the majority of their behaviour during the social task could be construed as "neutral." For the younger group, the total number of cooperative and competitive behaviours was positively skewed. When transformed into proportions, these behaviours remained positively skewed; however, because the proportion of "0" behaviour occurred frequently, a Logit transformation was not performed. For the older group, the total number of cooperative and competitive behaviours was positively skewed. When transformed into proportions only the proportion of competitive behaviours was positively skewed; however, because the proportion of "0" behaviour occurred frequently, a Logit transformation was not performed.

The relation between children's own behaviour and their partners' behaviour was examined (Table 8 for the younger group and Table 9 for the older group). These analyses revealed significant correlations between the children's behaviour and their partner's behaviour. In particular, cooperative behaviours were especially positively related, indicating that children very much affected each other's cooperative behaviours. As is often the case in dyadic

relationships, it is likely that children were influencing each other's thoughts, emotions and behaviours. In order to account for this finding in my main analyses, the Actor Partner Interdependence Model was used to examine relations between children's cognitive skills and their social behaviour (Kenny et al., 2006).

The relationship between children's behaviours during the cooperative social task and parent ratings of children's social skills was examined; however, there were no significant correlations between these variables,  $p > .05$ .

### **Relations between Cognitive Skills and Social Competence at Different Ages**

**Relations between cognitive skills and parent ratings of social skills.** The first aim of this study was to determine the unique relations between cognitive skills and parent ratings of social skills. Correlational analyses were conducted in order to investigate the relation between children's performance on the cognitive tasks and their social skills, as rated by parents (see Table 10 for the younger group and Table 11 for the older group).

In order to investigate the unique effects of each cognitive variable on social skills, partial correlations were conducted (see Table 10 for the younger group and Table 11 for the older group). Analyses revealed that, for the younger group, theory of mind was significantly correlated with parent-reported total social skill,  $r = .23$ ,  $p = .02$ , even when controlling for the other EF skills, vocabulary, and age.

For the older group, there were no significant partial correlations.

In summary, these results indicate that only children's theory of mind performance had a unique effect on social skills for the younger group. Specifically, younger children with better theory of mind were reported to have better overall social skill. For the older group, none of these cognitive variables had a unique effect on parent-reported social skill.

### **Relations between cognitive skills and parent ratings of social skills at different ages.**

To determine whether the unique relation between theory of mind and parent ratings of social skills changes at different ages, the significant partial correlation for the younger group was compared to the older group. The strength of the correlation between theory of mind and total social skill within the younger group was not significantly different from the older group,  $p > .05$ .

In summary, results indicate that theory of mind played a significant role in younger children's social skills; however, this effect was not significantly different from the older group.

**Dyadic models: relations between cognitive skills and social behaviours.** The first aim of this study included determining the unique relations between cognitive skills and on-line social behaviours during an interactive cooperative social task. The Actor Partner Interdependence Model allowed me to investigate the actor and partner effects of the cognitive skills on social behaviours (i.e., competitive and cooperative behaviours), while simultaneously controlling for the other predictor variables (i.e., EF, ToM, and verbal skills). To keep the models as simple as possible, the effect of each executive functioning component (i.e., planning, working memory, and inhibitory control) on social behaviour was examined in separate models, that is, as: 1) Planning, Theory of Mind, and Verbal Skills, 2) Working Memory, Theory of Mind, and Verbal Skills, and 3) Inhibitory Control, Theory of Mind, and Verbal Skills. If results indicated a significant effect of more than one executive function component, these components would be combined into one larger model in order to control for each executive function component. These models were run for each age group separately, as described below.

Figure 2 shows the structural model for the cooperative social task using the dependent variable of the proportion of competitive behaviours as an example. In this type of model, the

dyad members are treated as interchangeable (i.e., either could be assigned to partner A or partner B), and so all paired parameters are set equal across the members (Kenny, Kashy, & Cook, 2006). Each variable for a dyad is labelled as either A or B for each partner in the dyad. In this model, the actor effects for planning, theory of mind, and verbal skills are represented by paths *a*, *c*, and *e*, respectively; while the partner effects for planning, theory of mind, and verbal skills are represented by paths *b*, *d*, and *f*, respectively. In order to control for age, a composite of each pair's average age in months was calculated and this variable was added to the model, with a path going to partner A's behaviour and a path going to partner B's behaviour. This same type of model was run for each dependent variable (i.e., competitive or cooperative behaviour) and three sets of predictor variables—1) planning, theory of mind, and verbal skills, 2) inhibitory control, theory of mind and verbal skills, or 3) working memory, theory of mind and verbal skills—always controlling for age.

Significance was determined by an alpha value of less than .05. Please note that any significant results, as described below, were re-analyzed using the bootstrap analysis in order to better account for my skewed variables (see Appendix E). The key results that emerged across both the SEM and bootstrap analyses are summarized in Appendix F.

***Competitive behaviour.*** To begin, the effect of cognitive skills on the proportion of competitive behaviours was investigated. All parameter estimates are in standardized form.

First, to investigate the role of planning in the younger group, the model including planning (Tower task), theory of mind, vocabulary, and age as predictors of competitive behaviour was examined. Results are shown in Figure 3. Because the dyads were interchangeable (i.e., indistinguishable dyad members), the fit of the model has been adjusted using the I-SAT model (i.e., a saturated model where everything is modeled as related to

everything else in a completely unconstrained way). This model fit well,  $\chi^2(6, N = 65) = 6.69, ns$ , RMSEA = .04. Results for the actor effect of planning on the proportion of competitive behaviours was significant, while controlling for age and the actor and partner effects of the other predictor variables, ( $\beta = .19, p < .05$ ), indicating that younger children with better planning skills were displaying a greater proportion of competitive behaviours. On the other hand, the actor effect of theory of mind on the proportion of competitive behaviours was significantly negatively related, while controlling for age and the actor and partner effects of the other predictor variables, ( $\beta = -.37, p < .01$ ). Finally, the partner effect of theory of mind on the proportion of competitive behaviours was significantly negatively related, while controlling for age and the actor and partner effects of the other variables ( $\beta = -.23, p < .05$ ). These results indicate that, for the younger group, those with better theory of mind displayed a smaller proportion of competitive behaviours; furthermore, their theory of mind was having an effect on their partners' behaviours such that partners also displayed a smaller proportion of competitive behaviours.

For the older group, the model including planning, theory of mind, vocabulary, and age as predictors of competitive behaviour fit well,  $\chi^2(6, N = 59) = 3.84, ns$ , RMSEA = .00. Results for the actor effect of planning (i.e., Tower task) on the proportion of competitive behaviours was significant, while controlling for age and the actor and partner effects of the other predictor variables, ( $\beta = -.24, p < .01$ ), indicating that older children with better planning skills were displaying a smaller proportion of competitive behaviours. Furthermore, the actor effect of verbal skills (i.e., Vocabulary task) on the proportion of competitive behaviours was significant, while controlling for age and the actor and partner effects of the other predictor variables, ( $\beta = -.35, p < .01$ ). Finally, the partner effect of verbal skills on the proportion of competitive

behaviours was significant, while controlling for age and the actor and partner effects of the other variables ( $\beta = -.21, p < .05$ ). These results indicate that, for the older group, those with better verbal skills displayed a smaller proportion of competitive behaviours; furthermore, their verbal abilities were having an effect on their partners' behaviours such that partners also displayed a smaller proportion of competitive behaviours.

To investigate the role of inhibitory control (i.e., Go/No-go task) in the younger group, a model including inhibitory control, theory of mind, vocabulary, and age as predictors of competitive behaviour was examined. Because this model did not fit well when drawn as shown in Figure 2, this model was drawn as a saturated model with  $\chi^2(0, N = 65) = 0.00$  (i.e., there were zero degrees of freedom and the model had perfect fit). This did not affect the path coefficients from the predictor variables to the dependent variables. Similarly, a model including working memory (i.e., Finger Windows task), theory of mind, vocabulary, and age as predictors of competitive behaviour was drawn as a saturated model with  $\chi^2(0, N = 65) = 0.00$ . There were no significant actor or partner effects of inhibitory control or working memory on the proportion of competitive behaviours. It is noteworthy that the actor and partner effect of theory of mind remained significant in both of these models, controlling for inhibitory control and working memory.

For the older group, the model for inhibitory control (i.e., inhibitory control, theory of mind, vocabulary, and age as predictors of competitive behaviour) and the model for working memory (i.e., working memory, theory of mind, vocabulary, and age as predictors of competitive behaviour) fit well,  $\chi^2(6, N = 59) = 4.73$  and  $4.55, ns$ , RMSEA = .00. There were no significant effects of these executive functioning skills on competitive behaviour; however, the actor and partner effect of verbal skills remained significant or marginally significant in the older group,

when controlling for inhibitory control and working memory. Thus, when controlling for age, theory of mind and verbal skills, both older and younger children's inhibitory control and working memory do not appear to influence competitive behaviour displayed during a cooperative social task.

To summarize, these results indicate that different cognitive skills were having unique effects on competitive behaviours in each age group. While better planning skills were related to more competitive behaviours in younger children, better planning skills were related to fewer competitive behaviours in older children. Furthermore, while better theory of mind skills were related to fewer competitive behaviours in younger children and their partners, better verbal skills were related to fewer competitive behaviours in older children and their partners.

***Cooperative behaviour.*** Next, the effect of cognitive skills on the proportion of cooperative behaviours was investigated.

First, to investigate the role of planning in the younger group, the model including planning (Tower task), theory of mind, vocabulary, and age as predictors of cooperative behaviour was examined. This model fit well,  $\chi^2(6, N = 65) = 6.60, ns$ , RMSEA = .04. There were no significant effects of planning on the cooperative behaviour; however, there was a marginally significant actor effect of verbal skills on the proportion of cooperative behaviours ( $\beta = .19, p = .06$ ) and partner effect of verbal skills on the proportion of cooperative behaviours ( $\beta = .20, p = .05$ ). This indicates that, for the younger group, those with better verbal skills were displaying a greater proportion of cooperative behaviours (albeit marginally significant); furthermore, their verbal abilities were having an almost significant effect on their partners' behaviours such that partners also displayed a greater proportion of cooperative behaviours.

For the older group, the model including planning (Tower task), theory of mind, vocabulary, and age as predictors of cooperative behaviour fit well,  $\chi^2(6, N = 59) = 3.84$ , *ns*, RMSEA = .00. There were no significant effects of planning on the cooperative behaviour; however, the actor effect of theory of mind skills on the proportion of cooperative behaviours was marginally significant, ( $\beta = .18, p = .07$ ). This indicates that, for the older group, those with better theory of mind skills were displaying an almost significantly greater proportion of cooperative behaviours.

As described previously, the model for inhibitory control (i.e., inhibitory control, theory of mind, vocabulary, and age as predictors of cooperative behaviour) and the model for working memory (i.e., working memory, theory of mind, vocabulary, and age as predictors of cooperative behaviour) in the younger group were drawn as saturated models. There were no significant actor or partner effects of inhibitory control or working memory on the proportion of cooperative behaviours. Thus, when controlling for theory of mind and verbal skills, younger children's inhibitory control and working memory do not appear to influence cooperative behaviours displayed during a cooperative social task.

For the older group, the two separate models for inhibitory control and working memory fit well,  $\chi^2(6, N = 59) = 4.65$  and  $4.55$ , *ns*, RMSEA = .00. There were no significant effects of these executive functioning skills on cooperative behaviour.

To summarize, the cooperative behaviours in each group seemed to be somewhat influenced by different cognitive factors. While better verbal skills were marginally related to more cooperative behaviours in younger children as well as in their partners, better theory of mind skills were marginally related to more cooperative behaviours in older children.

### **Dyadic models: Comparisons of relations between cognitive skills and social**

**behaviours at different ages.** To investigate whether the younger and older groups differed with respect to the relations between cognitive skills and social behaviours during a cooperative social task, I applied a multiple-sample SEM in which a model for each dependent variable (i.e., competitive and cooperative behaviours) was applied simultaneously to the younger and older groups. The model for the younger group was identical to that for the older group, with corresponding parameters of  $a'$ ,  $b'$ ,  $c'$ ,  $d'$ , and so on. This allowed me to test whether the effect of each cognitive skill on social behaviours was significantly different between the age groups. Specifically, to test the hypothesis that the slopes of the predictor variables (both actor and partner effects) are different across the two age groups, I compared the fit of models where all paths were set different between the younger and older groups except a specific path of interest. For example, in one model the path for the actor effect of planning was set equal for both the younger and older groups. If there was a significant difference in fit for the original model and the constrained model, it would mean that there was a significant difference in the relation between planning and social behaviours between the two age groups. Only models with significant or marginally significant results in one of the age groups, as described above, were compared in the following analyses.

***Competitive behaviour.*** First, to examine the role of planning, the model with the predictor variables of planning, ToM, verbal skills, age and the dependent variable of the proportion of competitive behaviours was compared between the two age groups. To test the hypothesis that the slopes of the predictor variables (both actor and partner effects) were different across the two age groups, I compared the fit of models where a specific path in the younger group was set equal to the relevant path in the older group. In the first model, the path

for the actor effect of planning abilities was set equal for both the younger and older groups. The difference in fit between the original model and the constrained model was significant,  $\Delta\chi^2(1) = 8.67, p < .01$ . This indicates that the slope in the younger group was significantly different from the slope in the older group, meaning that planning abilities were having different effects on competitive social behaviours from the younger to older children. Whereas better planning was related to more competitive behaviours in the younger group, better planning was related to fewer competitive behaviours in the older group.

To examine the role of theory of mind skills, the path for the actor effect of theory of mind was set equal for the younger and older groups. The difference in fit was significant,  $\Delta\chi^2(1) = 12.90, p < .01$ . Also, when the path for the partner effect of theory of mind abilities was set equal for both the younger and older groups, the difference in fit was significant,  $\Delta\chi^2(1) = 5.11, p < .05$ . These results suggest that, when compared to the older group, theory of mind played a more significant role in the younger group such that better theory of mind was related to fewer competitive behaviours from oneself and one's partner.

To examine the role of verbal skills, the path for the actor effect of verbal abilities was set equal for the younger and older groups. The difference in fit was not significant,  $\Delta\chi^2(1) = 0.85, p > .05$ . Also, when the path for the partner effect of verbal abilities was set equal for both the younger and older groups, the difference in fit was not significant,  $\Delta\chi^2(1) = 0.98, p > .05$ . These results suggest that, verbal abilities did not play a significantly different role in affecting competitive behaviours across the two age groups.

In summary, these results indicate that certain cognitive skills were having different unique effects on the competitive behaviours displayed by younger versus older children. While better planning skills were related to more competitive behaviours in younger children, better

planning was related to fewer competitive behaviours in older children. Furthermore, theory of mind had a stronger effect on one's own and one's partner's competitive behaviour for the younger group (i.e., better theory of mind was related to fewer competitive behaviours).

***Cooperative behaviour.*** To examine the role of theory of mind in the model with the predictor variables of planning, ToM, verbal skills, age and the dependent variable of the proportion of cooperative behaviours, parameters were likewise compared between the two age groups. The actor effect for theory of mind did not differ significantly between the two age groups,  $\Delta\chi^2(1) = 2.28, p > .05$ . This result suggests that theory of mind abilities did not play a significantly different role in affecting children's cooperative behaviours across the two age groups.

To examine the role of verbal skills, the path for the actor effect of verbal abilities was set equal for the younger and older groups. The actor effect for verbal abilities did not differ significantly between the two age groups,  $\Delta\chi^2(1) = 0.22, p > .05$ . Furthermore, the partner effect of verbal abilities was not significantly different between the two age groups,  $\Delta\chi^2(1) = 0.23, p > .05$ . These results suggest that verbal abilities did not play a significantly different role in affecting one's own and one's partner's cooperative behaviours across the two age groups.

In sum, these results indicate that theory of mind and verbal skills did not have significantly different effects on cooperative behaviours between the younger and older groups.

### **Relations between Executive Functioning and ADHD versus ODD/CD Symptoms**

The second aim of this study was to investigate whether executive functions related to symptoms of ADHD (inattention and hyperactivity/impulsivity combined) while controlling for ODD/CD symptoms and vice versa. Recall that children's symptoms of ADHD and ODD/CD were rated by parents using the SNAP-IV Teacher and Parent Rating Scale, a revision of the

Swanson, Nolan and Pelham (SNAP) Questionnaire (Swanson et al., 1983). Symptoms of inattention and hyperactivity/impulsivity were significantly related for both the younger group,  $r = .76, p < .01$ , and the older group,  $r = .66, p < .01$ ; thus, they were combined into a general score of ADHD symptoms. As well, a general ADHD factor is supported by previous research (Gomez, Vance, & Gomez, 2013; Normand, Flora, Toplak, & Tannock, 2012). Symptoms of ODD and CD were also significantly related for both the younger group,  $r = .64, p < .01$ , and the older group,  $r = .65, p < .01$ ; thus, according to previous work, they were combined into one ODD/CD total score (e.g., Oosterlaan et al., 2005). Children's scores as rated by parents are presented in Table 12 for the younger group and older group. Because children completed measures of EF individually, I did not expect that their performance on the EF tasks would be influenced by their social partner; thus dyadic data analyses were not used. Correlational analyses were conducted to investigate the relation between executive function components and symptoms of ADHD and ODD/CD (see Table 13 for the younger group and Table 14 for the older group). In general, executive functions were not significantly related to ADHD or ODD/CD symptoms, with the exception of inhibitory control and ODD/CD symptoms in the older group.

In order to examine the unique relations of executive function components to each symptom profile, partial correlations were conducted to control for the other symptom profile and age (see Table 13 for the younger group and Table 14 for the older group). Analyses revealed that, for the younger group executive functions were not related to ADHD or ODD/CD while controlling for the other behavioural profile and age. For the older group there was a trend of inhibitory control (i.e., No-Go false alarm rate) being correlated with symptoms of ODD/CD even when controlling for symptoms of ADHD and age,  $r = .19, p = .07$ . This indicates that, for

the older group, weaker inhibitory control was marginally related to more symptoms of ODD/CD, even when controlling for symptoms of ADHD.

In summary, these results suggest that executive functions were not unique to symptoms of ADHD in either age group. In fact, only inhibitory control was marginally significantly related to symptoms of ODD/CD in the older group, when controlling for symptoms of ADHD.

### **Moderating Effects of Executive Functioning**

The third aim of this study was to explore whether EF components moderate the relationship between symptoms of ADHD or ODD/CD and social skills, as well as whether these relationships change with age. The bivariate correlations between parent ratings of social skill and symptoms of ADHD and ODD/CD are presented in Table 15 for the younger group and Table 16 for the older group. Both symptoms of ADHD and ODD/CD were strongly related to parent ratings of children's social skills. As well, the bivariate correlations between social behaviours during the social task and symptoms of ADHD and ODD/CD are presented in Table 17 for the younger group and Table 18 for the older group. Only ADHD symptoms were significantly related to the competitive behaviours during the cooperative social task.

Next, in order to examine the moderating effects of EFs and ADHD or ODD/CD, relevant interaction terms were calculated by first centering each relevant predictor variable around their means (i.e., IC, WM, Planning, ADHD and ODD/CD symptoms) and then creating a product term for each (i.e., IC x ADHD, WM x ADHD, Planning x ADHD; IC x ODD/CD, WM x ODD/CD, and Planning x ODD/CD).

**Moderating effects of executive functioning on parent ratings of social skills.** After an interaction term was created for each EF component and ADHD or ODD/CD symptoms, these variables were entered into structural equation models. Each symptom profile of interest

(i.e., ADHD or ODD/CD) was entered into a model with the relevant EF component (e.g., IC, WM, or Planning), the relevant interaction term and the dependent variable of Total Social skill as rated by parent report on the Strengths and Difficulties Questionnaire. These six models were run for each age group separately and, to test the unique effects of a significant interaction term, the other symptom profile and its interaction term were added to specific models as described below. Figure 4 shows the structural model for inhibitory control, ADHD, the interaction term, and the dependent variable Total Social skill. All parameter estimates presented below are in unstandardized form.

For the younger group, both models for ADHD and ODD/CD with IC and Planning fit well,  $\chi^2(1, N = 65) = 0.00$  to  $0.23$ , *ns*, RMSEA = .00. Because the model for WM and ADHD and the model for WM and ODD/CD did not fit well when drawn as Figure 4, they were drawn as saturated models. There were no significant effects of the interaction terms on Total Social skill.

For the older group, the model including working memory, ADHD, the interaction term, as predictors of Total Social skill was also drawn as a saturated model. This model revealed a main effect of ADHD symptoms ( $B = -.12$ ,  $p < .01$ ), indicating that as children have fewer ADHD symptoms they are more socially skilled. There was also a marginally significant interaction term; that is, the interaction of working memory and ADHD symptoms had a marginally significant effect on Total Social skill ( $B = .01$ ,  $p = .05$ ). This interaction effect indicates that ADHD symptoms have less of a negative effect on social skills when working memory is strong than when it is relatively weak (Figure 5). When ODD/CD symptoms and its interaction term were added into this model in order to control for this other symptoms profile and its interaction with working memory, it was drawn as a saturated model. In this model, the main effects of ADHD and ODD/CD were significant ( $B = -.08$ ,  $p = .01$  and  $B = -.12$ ,  $p = .03$ ,

respectively); however, the interaction effect of ADHD and working memory was no longer marginally significant ( $B = .00, p > .05$ ).

With the exception of the model for ODD/CD and WM, the models for ADHD and ODD/CD with IC, WM and Planning fit well,  $\chi^2(1, N = 65) = 0.04$  to  $2.03, ns$ , RMSEA = .00 to .09. The model for ODD/CD and WM was drawn as a saturated model. There were no significant effects of the interaction terms on Total Social skill.

To summarize, executive functioning did not interact with ADHD or ODD/CD symptoms to affect parent rated social skills in younger children. For older children, working memory and ADHD interacted to have a marginally significant effect on parent rated social skills; however, this interaction effect was not unique to ADHD, when controlling for the other symptom profile of ODD/CD and its interaction with working memory.

**Moderating effects of executive functioning on parent ratings of social skills at different ages.** As described previously, in order to investigate whether younger versus older children differ regarding the EF components that may moderate the relationship between ADHD symptoms and social skills (as well as, ODD/CD symptoms and social skills), I again applied a multiple-sample SEM in which a model for the dependent variable of Total Social skill was applied simultaneously to the younger and older groups. The model for the younger group was identical to that for the older group, with corresponding parameters of  $a'$ ,  $b'$ ,  $c'$ ,  $d'$ , and so on. This allowed me to test whether the interaction effect of an EF component and symptoms of ADHD (or ODD/CD) on social skill was significantly different between the age groups.

I examined the model with working memory, ADHD, the interaction term and the dependent variable of Total Social skill. To test the hypothesis that the interaction term was different across the two age groups, I compared the fit of a model where the path for the

interaction effect was set equal for both the younger and older groups. The interaction effect was significantly different between the two groups,  $\Delta\chi^2(1) = 4.73, p = .03$ . Working memory moderated the effect of ADHD more in the older group than the younger group to affect social skills. However, when controlling for ODD/CD symptoms and its interaction term, this difference was no longer significant  $\Delta\chi^2(1) = 1.25, p > .05$ .

In summary, the interaction effect of working memory and ADHD on parent rated social skills was significantly different between the younger and older group; however, this difference in the interaction effect was not unique to ADHD, when controlling for the other symptom profile of ODD/CD and its interaction with working memory.

**Dyadic models: moderating effects of executive functioning on social behaviours.**

In order to investigate the effect of the interaction terms on social behaviours for younger and older groups during an interactive cooperative social task, the Actor-Partner Interdependence Model was used. A model was created for each relevant EF component (e.g., IC, WM, or planning), the symptom profile being investigated (e.g., ADHD or ODD/CD), and the interaction term. Figure 8 shows the predictor variables of planning, ADHD, and the interaction term in relation to the dependent variable of competitive behaviours. Each dependent variable of key interest was modeled in turn (i.e., only the competitive or cooperative behaviours during the cooperative social task were examined). These models were run for each age group separately and, in order to test the unique effects of a significant interaction term, the other symptom profile and its interaction term were added to specific models as described below. All parameter estimates presented below are in unstandardized form.

***Competitive behaviour.*** When looking at symptoms of ADHD in the younger group, the models for inhibitory control and planning fit well,  $\chi^2(6, N = 65) = 6.50$  and  $4.86, ns$ ,

RMSEA = .04 and .00. The model for working memory did not fit well, thus was drawn as a saturated model. There were no significant effects of the interaction between ADHD and executive functions on the competitive behaviours in the younger group.

When looking at symptoms of ODD/CD in the younger group, the model for inhibitory control fit well,  $\chi^2(6, N = 65) = 6.02$ , *ns*, RMSEA = .01, and the models for planning and working memory were drawn as saturated models. There were no significant effects of the interaction between ODD/CD and these executive functions on the competitive behaviours in the younger group.

When looking at symptoms of ADHD in the older age group, the model including working memory, ADHD, the interaction term and the dependent variable competitive behaviours fit well,  $\chi^2(6, N = 59) = 4.91$ , *ns*, RMSEA = .00, and revealed a significant partner main effect of ADHD symptoms ( $B = .03$ ,  $p = .04$ ), indicating that as children have more ADHD symptoms their partners displayed more competitive behaviours. There was also a significant interaction term; that is, the interaction of working memory and ADHD symptoms had a significant actor effect on competitive behaviours ( $B = -.02$ ,  $p < .01$ ). This interaction effect showed that if older children had worse working memory, more ADHD symptoms were related to more competitive behaviours; whereas, if they had relatively better working memory, this relationship was no longer positive (Figure 6). When adding ODD/CD and its interaction term to this model, in order to control for this other symptom profile and its interaction with working memory, this model was drawn as a saturated model. While the partner main effect of ADHD was no longer significant, the interaction effect of ADHD and working memory remained significant ( $B = -.02$   $p < .01$ ). This suggests that the interaction between ADHD and working

memory had a unique effect on competitive behaviour, even when controlling for ODD/CD and its interaction with working memory.

The model including planning, ADHD, the interaction term and the dependent variable competitive behaviours fit well,  $\chi^2(6, N = 59) = 4.23$ , *ns*, RMSEA = .00, and revealed a significant partner main effect of ADHD symptoms ( $B = .03$ ,  $p = .01$ ), indicating that as children have more ADHD symptoms their partners display more competitive behaviours. There was also a significant interaction term; that is, the interaction of planning skills and ADHD symptoms had a significant actor effect on competitive behaviours ( $B = -.03$ ,  $p < .01$ ). This interaction effect indicated that if older children had worse planning skills, more ADHD symptoms were related to more competitive behaviours; whereas, if they had relatively better planning skills, this relationship was no longer positive. When adding ODD/CD and its interaction term to this model, in order to control for this other symptom profile and its interaction with planning, this was drawn as a saturated model. While the partner main effect of ADHD was no longer significant, the interaction effect of ADHD and planning remained significant ( $B = -.04$ ,  $p < .01$ ). This suggests that the interaction between ADHD and planning had a unique effect on competitive behaviour, even when controlling for ODD/CD and its interaction with planning. In addition, there was a significant partner main effect of ODD/CD symptoms on competitive behaviours ( $B = .07$ ,  $p = .01$ ).

The model including inhibitory control, ADHD, the interaction term and the dependent variable competitive behaviours fit well,  $\chi^2(6, N = 59) = 5.01$ , *ns*, RMSEA = .00; however, there was no significant interaction effect of ADHD and inhibitory control on competitive behaviours in the older group.

When looking at symptoms of ODD/CD in the older group, the model including working memory, ODD/CD, the interaction term and the dependent variable competitive behaviours was drawn as a saturated model. There was no significant interaction effect of ODD/CD and working memory on competitive behaviours.

The model including planning, ODD/CD, the interaction term and the dependent variable competitive behaviours was drawn as a saturated model. This revealed a significant partner main effect of ODD/CD symptoms ( $B = .11, p < .01$ ). There was also a significant interaction term, that is, the interaction of planning skills and ODD/CD symptoms had a significant actor effect on competitive behaviours ( $B = -.03, p = .01$ ). This interaction effect showed that if older children had worse planning skills, more ODD/CD symptoms were related to more competitive behaviours; whereas, if they had relatively better planning skills, this relationship was no longer positive. When adding ADHD and its interaction term to this model, in order to control for this other symptom profile and its interaction with planning, this was drawn as a saturated model. The partner main effect of ODD/CD remained significant ( $B = .07, p = .01$ ); the interaction effect of ODD/CD and planning was no longer significant ( $B = .01, p > .05$ ). This suggests that the interaction between ODD/CD and planning did not have a unique effect on competitive behaviour, when controlling for ADHD and its interaction with planning.

Finally, the model including inhibitory control, ODD/CD, the interaction term and the dependent variable competitive behaviours fit well,  $\chi^2(6, N = 59) = 7.04, ns$ , RMSEA = .05, and revealed a significant actor and partner main effect of ODD/CD symptoms ( $B = .05, p = .04$  and  $B = .07, p < .01$ , respectively). There was also a significant interaction term; that is, the interaction of inhibitory control and ODD/CD symptoms had a significant partner effect on competitive behaviours ( $B = .39, p = .04$ ). This interaction effect indicates that the positive

relationship between ODD/CD symptoms and partners' competitive behaviours in older children becomes stronger as inhibitory control becomes worse. When adding ADHD and its interaction term to this model, in order to control for this other symptom profile and its interaction with inhibitory control, this model was drawn as a saturated model. While the actor main effect of ODD/CD symptoms was no longer significant, the actor main effect of ADHD symptoms was significant ( $B = .04, p = .03$ ). The partner main effect of ODD/CD symptoms remained significant ( $B = .07, p = .03$ ); however, the partner interaction effect of ODD/CD and inhibitory control was no longer significant. This suggests that the interaction between ODD/CD and inhibitory control did not have a unique effect on partners' competitive behaviour, when controlling for ADHD and its interaction with inhibitory control.

To summarize, these results indicate that only in the older group did executive functions interact with different symptom profiles to uniquely affect competitive behaviours. Specifically, working memory and planning skills interacted with ADHD symptoms to uniquely affect older children's competitive behaviour, even when controlling for the other symptom profile of ODD/CD and its interaction with working memory and planning skills. Interestingly, only symptoms of ODD/CD had a unique main effect on partners' competitive behaviours when controlling for ADHD symptoms, such that as ODD/CD symptoms increased so did partners' competitive behaviours.

***Cooperative behaviour.*** When looking at symptoms of ADHD in the younger group, the models for inhibitory control and planning fit well,  $\chi^2(6, N = 65) = 7.02$  and  $4.83, ns$ ,  $RMSEA = .05$  and  $.00$ , and the model for working memory was drawn as a saturated model. There were no significant effects of the interaction between ADHD and these executive functions on cooperative behaviours in the younger group.

When looking at symptoms of ODD/CD in the younger group, the model for inhibitory control fit well,  $\chi^2(7, N = 65) = 6.28, ns$ , RMSEA = .03. The models for planning and ODD/CD and working memory and ODD/CD were drawn as saturated models. There were no significant effects of the interaction between ODD/CD and these executive functions on cooperative behaviours in the younger group.

For the older group, the model including inhibitory control, ADHD, the interaction term and the dependent variable cooperative behaviours fit well,  $\chi^2(6, N = 59) = 6.10, ns$ , RMSEA = .02, and revealed two significant interaction terms. That is, the interaction of inhibitory control and ADHD symptoms had a significant actor and partner effect on cooperative behaviours ( $B = 3.80, p = .04$  and  $B = 4.32, p = .02$ , respectively). This interaction effect indicated that if older children had better inhibitory control, fewer ADHD symptoms were related to more cooperative behaviours; whereas, if they had relatively worse inhibitory control, this relationship reversed (Figure 7, part A). As well, the interaction of children's inhibitory control and ADHD had a significant effect on their partners' cooperative behaviours. This interaction effect indicated that if older children had better inhibitory control, fewer ADHD symptoms were related to more cooperative behaviours from partners; whereas, if they had relatively worse inhibitory control, this relationship was no longer positive (Figure 7, part B). When adding ODD/CD and its interaction term to this model, in order to control for this other symptom profile and its interaction with inhibitory control, this model was drawn as a saturated model and the actor and partner interaction effects of ADHD and inhibitory control remained significant ( $B = 6.83, p = .04$  and  $B = 7.08, p = .03$ , respectively). This suggested that the interaction between ADHD and inhibitory control had a unique effect on one's own and one's partner's cooperative behaviour, even when controlling for ODD/CD and its interaction with inhibitory control.

When looking at symptoms of ADHD in the older group, the model for working memory fit well,  $\chi^2(6, N = 59) = 3.31$ , *ns*, RMSEA = .00, and the model for planning was drawn as a saturated model. There were no significant effects of the interaction between ADHD and these executive functions on cooperative behaviours in the older group.

When looking at symptoms of ODD/CD in the older group, the model for inhibitory control fit well,  $\chi^2(6, N = 59) = 6.37$ , *ns*, RMSEA = .03. The models for working memory and planning were drawn as saturated models. There were no significant effects of the interaction between ODD/CD and these executive functions on cooperative behaviours in the older group.

To summarize, results demonstrate that only in the older group did executive functions interact with different symptoms profiles to affect cooperative behaviours. Specifically, inhibitory control skills interacted with ADHD symptoms to uniquely affect one's own and one's partner's cooperative behaviour, even when controlling for the other symptom profile of ODD/CD and its interaction with inhibitory control. On the other hand, no executive functions interacted with ODD/CD symptoms to uniquely affect cooperative behaviour.

**Dyadic models: moderating effects of executive functioning on social behaviours at different ages.** To investigate whether older versus younger children differ regarding the EF components that may moderate the relationship between ADHD symptoms and social behaviours (as well as, ODD/CD symptoms and social behaviours), a multiple-sample SEM was again applied in which a model for each dependent variable (i.e., cooperative or competitive behaviour) was applied simultaneously to the younger and older groups. As in the foregoing analyses, in order to test whether a significant difference between age groups is unique to the interaction between a particular symptom profile (i.e., ADHD versus ODD/CD) and executive function, the other symptom profile and its interaction term were added to specific models, as

described below. Only models with significant or marginally significant results in one of the age groups, as described above, were compared in the following analyses.

**Competitive behaviour.** First, the model with working memory, ADHD, the interaction term and the dependent variable of competitive behaviour was examined. The interaction actor effect differed between the two age groups at a marginal level,  $\Delta\chi^2(1) = 2.91, p = .08$ . This result suggested that working memory moderated symptoms of ADHD more in the older age group than the younger age group to affect competitive behaviour. However, when controlling for ODD/CD symptoms and its interaction term, this difference was no longer significant,  $\Delta\chi^2(1) = 2.17, p > .05$ . This suggested that the difference in the interaction effect between age groups was not unique to ADHD, when controlling for ODD/CD and its interaction with working memory. It is also noteworthy that the partner main effect of ADHD was not significantly different between the two age groups,  $\Delta\chi^2(1) = 0.21, p > .05$ .

When examining the model with planning, ADHD, the interaction term and the dependent variable of competitive behaviour, the interaction actor effect was significantly different between the two groups,  $\Delta\chi^2(1) = 10.86, p < .01$ . This indicated that planning moderated the effect of symptoms of ADHD more in the older age group than the younger age group to affect competitive behaviour. Even when controlling for ODD/CD symptoms and its interaction term, this difference remained significant,  $\Delta\chi^2(1) = 6.50, p = .01$ . This suggested that the difference in the interaction effect between age groups was unique to ADHD, even when controlling for ODD/CD and its interaction with planning. It is noteworthy that the partner main effect of ADHD was not significantly different between the two groups,  $\Delta\chi^2(1) = 0.02, p > .05$ .

I then examined the model with inhibitory control, ODD/CD, the interaction term and the dependent variable of competitive behaviour. The difference between groups for the interaction

partner effect was not significant,  $\Delta\chi^2(1) = .04, p > .05$ . It is also noteworthy that the partner main effect of ODD/CD was not significantly different between the two groups,  $\Delta\chi^2(1) = 0.28, p > .05$ .

I then examined the model with planning, ODD/CD, the interaction term and the dependent variable of competitive behaviour. The interaction actor effect was significantly different between the two groups,  $\Delta\chi^2(1) = 6.54, p = .01$ . This indicated that planning moderated the effect of symptoms of ODD/CD more in the older age group than the younger age group to affect competitive behaviour. However, when controlling for ADHD symptoms and its interaction term, this difference was no longer significant,  $\Delta\chi^2(1) = 0.00, p > .05$ , and thus not unique to ODD/CD, when controlling for ADHD and its interaction with planning. It is also noteworthy that the partner main effect of ODD/CD was not significantly different between the two groups,  $\Delta\chi^2(1) = 0.12, p > .05$ .

In summary, these results suggest that only ADHD symptoms and planning abilities interacted differently for younger and older children to affect competitive behaviour, even when controlling for the other symptom profile of ODD/CD and its interaction with planning. Specifically, only when older children have worse planning skills, are more ADHD symptoms related to more competitive behaviours; whereas, when they have relatively better planning skills, this relationship is no longer positive.

***Cooperative behaviour.*** In the model with inhibitory control, ADHD, the interaction term and the dependent variable of cooperative behaviour, the interaction actor effect was significantly different between the two groups,  $\Delta\chi^2(1) = 5.19, p = .02$ , as was the interaction partner effect,  $\Delta\chi^2(1) = 7.71, p < .01$ . This indicated that inhibitory control interacted with symptoms of ADHD more in the older age group than the younger age group to affect one's own

cooperative behaviours and one's partner's cooperative behaviours. Even when controlling for ODD/CD symptoms and its interaction term, this difference for the interaction actor effect and the partner effect remained significant,  $\Delta\chi^2(1) = 5.84, p < .05$  and  $\Delta\chi^2(1) = 8.67, p < .01$ .

In summary, these results indicate that only ADHD symptoms and inhibitory control interacted differently for younger and older children to affect cooperative behaviour, when controlling for the other symptom profile of ODD/CD and its interaction with inhibitory control. Specifically, only when older children have better inhibitory control, are fewer ADHD symptoms related to more cooperative behaviours from children and their partners; whereas, when they have relatively worse inhibitory control, these relationships are no longer positive.

As noted above, significant or marginally significant results from the SEM analyses, described above, were re-analyzed using the bootstrap analysis (see Appendix E). The key results from both these analyses are summarized in Appendix F.

## Discussion

### Overview

Learning to engage in a socially appropriate manner with one's peers is an important developmental task that impacts children's later development. As such, it is important to understand which cognitive skills facilitate socially appropriate behaviour (and how), as well as how these skills interact with externalizing behaviours in order to affect social interactions. With this overarching theme in mind, this dissertation sought to accomplish three main goals. The first aim of this study was to determine the unique contributions of EF components, ToM and verbal skills on socially competent behaviour and whether different cognitive skills (e.g., components of EF) are related to social competence at different ages. It was expected that EFs would have unique effects on social behaviours and the relations among EF components and social competence would change with age. The second aim was to investigate whether EF related to symptoms of ADHD or ODD/CD, while controlling for the other symptom profile. Finally, this study explored whether EF components moderate the relationship between symptoms of ADHD or ODD/CD and social skills, while controlling for the other behavioural profile, and how these relationships change with age. To address these research aims, a task that allowed observation of children's behaviours while interacting with another child was used. Furthermore, children's everyday social behaviours and symptoms of ADHD and ODD/CD were assessed through parent report measures. Finally, children were administered individual tasks intended to assess their EF, ToM, and verbal skills.

As a conservative approach, only results that demonstrated a consistent pattern between the SEM and bootstrap analyses will be interpreted and discussed here. Overall, results from this study highlight the interplay between cognitive skills, externalizing behaviour symptoms and stage of development on children's socially competent behaviours.

Before addressing the research questions, it was important to examine the measures used to assess cognitive skills. Results indicated that the measures assessing EF, ToM, and verbal skills demonstrated good variability in both age groups, suggesting that they were age-appropriate for the younger and older groups. Moreover, for the younger group, the tasks were significantly correlated with each other and with age. This finding is similar to previous research where these cognitive skills have been found to be significantly related to one another (Carlson & Moses, 2001; Carlson, Moses, & Breton, 2002; Carlson, Moses, & Claxton, 2004; Hughes & Ensor, 2007). On the other hand, for the older group, only working memory, ToM, and verbal skills were correlated with one another. This pattern is consistent with some research and theoretical accounts positing that as children develop, EF components become more differentiated and the relations between cognitive skills change (Best et al., 2009; Huizinga & van der Molen, 2007). On the other hand, newer research has shown that the structure of EF components becomes more stable even by six years and older (McAuley & White, 2011). In the end, these results and past research show that EF components are separable abilities, which underscores the importance of using individual components of EF, rather than an overall EF composite, when looking at the relations between EF and other variables (e.g., social behaviours; Best et al., 2009; McQuade et al., 2013).

To understand how children were affecting each other during the social interaction, the relationship between children's behaviours was also examined. These preliminary analyses indicated that children's behaviour and their social partner's behaviour during the interactive social task were significantly related. This suggests that children have an influence on their partner's behaviours, which is similar to findings in past research (e.g., Huyder & Nilsen, 2012). In the current study, it may be that children are using cues from their social partners to guide

their own behaviour and/or are simply reciprocating the behaviour of their social partner. Past research has found that children are more likely to share resources with those who have shared with them in the past, that is, to reciprocate (Olson & Spelke, 2008). Because of this mutual influence between social partners, the current study examined actor and partner effects when looking at the relation between children's cognitive skills and social behaviour during the social interaction with a partner.

When examining the relationship between children's behaviours during the cooperative social task and children's social skills as rated by parents, it was found that these two different measures of children's social functioning were not related. This finding suggests that the two social measures may be capturing different aspects of children's social competence and highlights the importance of assessing children's social competence using different methods. Specifically, in-lab tasks capture specific social behaviours in a more structured context versus parent reports of social skills which assess global aspects of social functioning across a number of contexts (Huang-Pollock et al., 2009).

### **Unique Contributions of Cognitive Skills to Social Competence at Different Ages**

The first main goal of this study was to investigate the unique influences that EFs, ToM, and verbal skills have on children's social behaviours and whether these relationships change at different ages. These relationships were investigated using both parent reports of their children's social behaviour and children's behaviour during an interactive cooperative social task. The patterns found regarding the different cognitive skills (i.e., EFs, ToM, and verbal skills) and these different assessments of social functioning will be discussed in turn.

Although children's executive functioning skills did not play a role in predicting parent reports of social behaviours, results from the interactive social task revealed that planning skills

had an effect on children's social behaviours. Specifically, it was found that planning skills had a unique (when controlling for the other cognitive skills) and opposite effect on children's competitive behaviours for the younger versus older children. While better planning skills were related to *more* competitive behaviours in the younger group, better planning skills were related to *fewer* competitive behaviours in the older group.

These findings indicate that the relationship between planning skills and social competence changes with age as planning skills develop. Interestingly, better planning in younger children was related to increased 'inappropriate' competitive behaviours during the cooperative social task. It may be that younger children hold a different goal in mind; that is, they are generally more focused on completing their individual portion of the task. Indeed, literature on the development of social competence highlights that younger children tend to be more "self-focused" and gradually become more aware of others' thoughts, feelings, and expectations and place more value on peer acceptance beyond early childhood (Rose-Krasnor, 1997). As such, those with better planning skills would show more behaviours that are more in line with self-serving goals (e.g., taking and using a block that their partner needed to complete their own half of the wooden model). It may also be the case that the younger children are not able to utilize planning abilities in an efficient or competent manner in order to act in a more socially appropriate and collaborative way. Related, their other cognitive skills (e.g., inhibitory control, working memory, ToM) may not yet be well-developed enough to support their planning skills to guide more appropriate behaviours (Best et al., 2009) or to manage the demands of a complex social situation where they must work both towards gains for oneself and one's partner (i.e., a collaborative, rather than self-serving goal). In contrast, it seems that older children are able to use their planning skills to guide more socially appropriate behaviours. That is, in

contrast to younger children, older children's planning skills may be better supported by their other more well-developed cognitive abilities (e.g., inhibitory control, working memory; Best et al., 2009). Consequently, older children with better planning skills are likely better able to focus on the collaborative goal and how to most effectively coordinate one's own goals with another's. For the interactive social task used in this study, planning could allow children to recognize how different actions would lead to the end goal of winning the most points for their team, and thus, choose to limit actions that would be beneficial for oneself but would hinder this team effort (e.g., taking a partner's block that would be needed by that partner to get more bonus points).

In contrast to the effects of planning, working memory and inhibitory control did not have unique effects on children's social behaviours as assessed by the parent-reported social skills or the interactive social task. It is unclear why working memory and inhibitory control did not have a significant impact on either younger or older children's social skills. It may be that these EF components were not particularly helpful for guiding children's behaviours as measured by my specific laboratory task or for the parent-reported questionnaire. It is also possible that the specific tasks used to assess inhibitory control and working memory are generally not relevant to social behaviours. For example, while one recent study did find relations between *verbal* working memory and social functioning (i.e., peer rejection) as assessed by teacher reports, it did not find a relationship between *spatial* working memory and social competence (McQuade et al., 2013). As well, inhibitory control can be divided into different types, such as, cognitive inhibition or motor response inhibition (Nigg, 2000). A limitation of the current study is the use of only one measure of working memory or inhibitory control, specifically *spatial* working memory and *motor response* inhibition. Future studies could include more tasks that tap different types of working memory (including verbal working memory) and inhibitory control (including

cognitive inhibition), in order to create a composite measure of these components that would be more comprehensive and reliable (Miyake et al., 2000).

In regards to ToM abilities, results pertaining to parent-reported social skill indicate that ToM had a unique effect on younger children's social skills. Specifically, better ToM was related to better reported social skill in the younger group. The relation between ToM and social skills in the younger group was not significantly different from the older group. This indicates that while ToM plays a significant role in guiding parent-reported social skill for the younger group, it may not play a more central role for the younger group than the older group.

ToM was also found to play a facilitating role for younger children's social behaviours within the context of an interactive social task. Specifically, better ToM was related to fewer competitive behaviours from younger children and their partners. Moreover, these actor and partner effects were significantly different from the effects of ToM in older children; thus, ToM seems to play a more prominent role in guiding younger children's, and their partners', competitive behaviours during the cooperative social task. Taken together, results from parent-reported social skill and social behaviours during an interactive social task indicate that ToM skills are especially important in helping younger children enact social behaviours that will lead to more appropriate interactions with their peers. Moreover, ToM appears to have a unique effect on social behaviours, even when controlling for EFs (i.e., planning, inhibitory control, and working memory) and verbal skills.

Why would ToM play a unique role in guiding social behaviour in younger children? Younger children tend to act more egocentrically and their social skills are not yet well-developed. Being successful in social interactions during early childhood involves an increasing awareness of others and being able to successfully engage in play with peers, which would

involve ToM (i.e., being able to understand the mental states of others; Denham, Salisch, Olthof, Kochanoff, & Caverly, 2002). Younger children who have better ToM (i.e., the ability to understand other's mental states and feelings) would then understand another's perspective in order to act in a way that is socially appropriate and would lead to more successful play interactions with peers (Razza & Blair; Hughes & Leekam; Bosacki & Astington, 1999). Indeed, ToM has been shown to play an important role in children's developing social competence (Hughes & Leekam, 2004). For example, preschool-age children with weaker ToM demonstrate more conflict behaviour with other children (Dunn & Cutting, 1999). Furthermore, ToM, as measured by "false-belief understanding," has been shown to be related to social competence in young children (3-6 years old), independent of EF and verbal skills (Razza & Blair, 2009). The results from the current study provide additional evidence that ToM does indeed have a unique effect on children's social behaviours, particularly for younger children, even when controlling for EFs and verbal skills. It is also noteworthy that children's own ToM had a significant effect on their partners' competitive behaviours. To the author's knowledge, this has not been investigated in past research. This partner effect may occur because children with better ToM act in a manner that demonstrates understanding and consideration for the other person, which in turn, would lead the other person to behave less competitively than they would otherwise. In other words, younger children may be more inclined to behave in a less self-serving way with someone who demonstrates more consideration for others, a pattern that has been shown in past research (e.g., Olson & Spelke, 2008).

While ToM was related to *younger* children's competitive behaviours, results showed that ToM skills facilitated more cooperative behaviours from children in the *older* group. It may be that when children are younger, ToM aids them to not act inappropriately (i.e., competitively);

however, as children become older and develop better ToM skills, these better developed skills may enable them to be more attuned to the collaborative goals and as such act in more prosocial ways (i.e., cooperatively).

Together, then, pattern of results suggests that ToM helps these two age groups solve the interactive social task in different ways. As mentioned above, it may be that children's developing ToM leads to different behaviours from younger to older children. Both these patterns of behaviour qualify as socially appropriate; however, one is more advanced and socially complex than the other. Specifically, ToM helps younger children to behave in a less competitive manner; however, ToM helps older children behave more cooperatively. This latter solution is a more advanced social endeavour, as one must keep in mind the goals and needs of one's partner and act in a way that will lead to a collaborative goal (cooperation). This is in line with past research that would suggest that, as ToM skills develop further (e.g., from first order to second order ToM), these skills will aid children in solving increasingly complex social situations (Flynn, 2010; Moses & Tahiroglu, 2010).

Finally, when examining the contributions of verbal skills on social behaviour, it was found that verbal abilities had a unique effect on the competitive behaviour of older children during the interactive social task. Specifically, even when controlling for other cognitive skills, older children with better verbal skills displayed fewer competitive behaviours; as well, their partner displayed fewer competitive behaviours. These effects, however, were not significantly different between older and younger children.

It is curious that verbal skills played such an important and unique role in influencing children's and their partners' behaviours. It may be the case that children with better verbal skills were simply better able to understand the instructions and goals of the cooperative task, in order

to guide their own behaviour and use self-talk during the task to keep themselves on course for their goals. Furthermore, children with better verbal skills may be better able to communicate with their partner in a manner that decreases their partner's self-serving (competitive) behaviours. Specifically, better verbal skills may allow a child to negotiate more effectively with their partner and assert what each person should be doing during the task, such as reminding the partner of their joint goal and behaviours that will not benefit the team. Using my coding system for children's behaviours during the social task, any types of verbalizations that were about the "team" would be coded as cooperative. Past research has also found that verbal ability is related to aspects of social functioning, particularly assertiveness and externalizing behaviour (Moffitt, 1990; Nigg et al., 1999).

### **Relationship of Executive Functioning to ADHD versus ODD/CD Symptoms**

The second goal of this study was to investigate whether specific EF components relate to symptoms of ADHD or ODD/CD, while controlling for the other symptom profile. It was found that EFs (i.e., inhibitory control, working memory, and planning) as measured in this study were not related to symptoms of ADHD in either age group. On the other hand, inhibitory control was marginally significantly related to symptoms of ODD/CD in the older group, while controlling for symptoms of ADHD. These results suggest that, within this sample of children, inhibitory control deficits are somewhat unique to ODD/CD symptoms.

This finding was not expected, given past research has shown that inhibitory control is uniquely related to symptoms of ADHD and there are inhibitory control deficits in ADHD samples compared to control groups (Berlin & Bohlin, 2002; Brocki et al., 2007; Willcutt, et al., 2005). In addition, while there is some research to suggest that CD involves inhibitory control deficits (Oosterlaan et al., 1998; Raaijmakers et al., 2008; Sergeant et al., 2002), other studies

have found that response inhibition is not related to ODD/CD when controlling for ADHD (Berlin & Bohlin, 2002; Brocki et al., 2007). Furthermore, it is curious that working memory and planning skills were not related to ADHD or ODD/CD, given deficits related to these two disorders found in past research (e.g., Willcutt et al., 2005; Brocki et al., 2008; Klorman et al., 1999). However, there are other studies that have not found a relationship between these EF components and ADHD or ODD/CD (e.g., Brocki et al., 2007; Geurts et al., 2005). It is also possible that the way ADHD and ODD/CD symptoms were measured in the present study led to this discrepant result. Specifically, using only parent reports to assess ADHD and ODD/CD symptoms may not be as reliable or valid as including teacher reports or clinician administered diagnostic interviews. Future studies could also assess these symptoms using more rigorous methods (e.g., diagnostic interviews). Furthermore, participants in this study were from a typically developing population and the presence of ADHD and ODD/CD symptoms was relatively low compared to a clinical sample. The intention was to capture symptoms of ADHD or ODD/CD along a broader dimension, rather than a clinical sample where severity of symptoms would be more restricted; however, the current sample likely did not fully capture this more extreme end of the continuum. It will be important for future studies to also recruit participants that exhibit more clinically relevant symptoms of ADHD and/or ODD/CD in order to better represent the broader range of these symptoms.

### **Moderating Effects of Executive Functioning**

Finally, the third goal of this study was to explore whether EF components moderate the relationship between symptoms of ADHD or ODD/CD and social skills and how these relationships change with age. This was examined using both parent ratings of social skill and children's on-line social behaviours during the interactive cooperative social task. The patterns

found using these different approaches to capture children's social behaviour will be discussed in turn.

When looking at parent ratings of social skills, results indicate that working memory and ADHD interacted to have an effect on social behaviours within the older group. In addition, ADHD and ODD/CD symptoms had a significant main effect on social skill, such that, higher levels of these symptoms were related to weaker social skills. These results suggest that ADHD symptoms have less of a negative effect on social skills when working memory is strong than when it is relatively weak; thus, working memory may help to alleviate some of the social difficulties that typically arise in children with more ADHD symptoms. These results corroborate past research, which found that EFs interacted with ADHD symptoms to affect peer ratings of social competence (Diamantopoulou et al., 2007). However, this interaction effect was no longer significant when controlling for symptoms of ODD/CD. Thus, it seems that the interaction of working memory and ADHD symptoms on social behaviours as rated by parents is not unique to ADHD symptoms.

To this author's knowledge, this is the first study to look at this interaction effect, while controlling for ODD/CD symptoms and provides some evidence that the moderating effects of working memory on ADHD symptoms to affect social skill is not unique to this symptom profile. However, this finding is viewed somewhat cautiously as it is limited by the way social skill was measured, using only parent ratings. Some authors have suggested that teacher and parent reports, although useful because they can provide a global assessment of children's social skill, are limited in their ability to index "molecular social behaviours" and can be influenced by reporter bias or halo effects (Huang-Pollock et al., 2009). Thus, it was important to also look at children's on-line social behaviours, as done in this dissertation.

When examining children's social behaviours during an interactive social task, EF interacted with the different symptom profiles of ADHD and ODD/CD to affect children's own and their partners' behaviours. However, similar to the interaction effects with parent ratings of social skill, these interaction effects occurred only within the older group of children.

It was found that working memory interacted with ADHD symptoms to uniquely affect older children's competitive behaviour, while controlling for ODD/CD. That is, if older children had worse working memory, ADHD symptoms were positively related to competitive behaviours; whereas, if they had relatively better working memory, this relationship was no longer positive. Working memory skills also interacted with ODD/CD symptoms to affect older children's behaviour, but this effect was no longer significant when controlling for ADHD. Together, then, these results demonstrate that the interaction effect of working memory and ADHD appears to be unique to this symptom profile. Similar to the findings from the parent ratings of social skills, these results suggest that proficient working memory may help to alleviate some of the social difficulties that typically arise in children higher on ADHD symptoms. Thus, while working memory itself does not seem to play a unique role in affecting social behaviour, it is having an effect on social behaviour when interacting with ADHD symptoms.

With regards to other EF skills, results yielded a significant interaction effect of inhibitory control and ADHD symptoms on children's own and their partner's cooperative behaviour, while controlling for ODD/CD. Furthermore, these interaction effects were significantly different between the younger and older group, in that inhibitory control interacted with symptoms of ADHD to a greater extent in the older group to affect children's own and their partner's cooperative behaviour. The actor interaction effect revealed that if older children had

better inhibitory control, fewer ADHD symptoms were related to more cooperative behaviours; whereas, if they had relatively worse inhibitory control, this relationship reversed. The effect of inhibitory control was most apparent when there were fewer reported ADHD symptoms. This implies that children are most able to collaborate with another social actor when they have both few symptoms of ADHD and also better inhibitory control skills. The partner interaction effect showed that if older children had better inhibitory control, fewer ADHD symptoms were related to more cooperative behaviours from partners; whereas, if they had relatively worse inhibitory control, this relationship was no longer positive. So again, as a child's ADHD symptoms decrease, inhibitory control has a much greater effect on his/her partner's cooperative behaviours. Thus, it seems that if children are functioning quite well in regards to having fewer ADHD symptoms and better inhibitory control, partners demonstrate more cooperative behaviours. It could be that older children attend to their partners' characteristics and behave more 'positively' (i.e., cooperatively) towards children who have more 'attractive' characteristics (i.e., fewer ADHD symptoms and better inhibitory control skills). Indeed past research shows that children tend to act more positively (e.g., share resources) towards those with certain attractive characteristics (e.g., generosity; Olson & Spelke, 2008).

It is interesting to consider why inhibitory control would be playing a more prominent role when children have fewer ADHD symptoms. That is, in the present study, inhibitory control appears to have the most effect on *cooperative* behaviour at low levels of ADHD symptoms, but it does not seem to have much effect at higher levels of ADHD. These results are in-line with past findings showing that low levels of EF deficit in combination with low levels of ADHD symptoms are associated with higher peer nominations of prosocial behaviour (Diamantopoulou et al., 2007). It may simply be that in order to behave in a more advanced, socially appropriate

manner (i.e., collaboratively) children require optimal functioning, that is, few ADHD symptoms and better inhibitory control. In another vein, there is a particular line of research indicating that inhibitory control, specifically motor response inhibition, is an endophenotype of ADHD and may lead to the behavioural manifestations of ADHD (i.e., phenotype; Crosbie, Pérusse, Barr, & Schachar, 2008; Crosbie et al., 2013). Accordingly, inhibitory control would tend to be consistently low for those high on ADHD symptoms, which may account for the behavioural manifestations of ADHD. Thus, it may be the case that inhibitory control does not have a significant influence on behaviour for children with high levels of ADHD because there is less variability in the inhibition levels at this ADHD range. However, this proposition is speculative because, as mentioned previously, my sample did not include many participants at the extreme end of the ADHD continuum; thus, I am not able to draw conclusions about this from my data.

In contrast, as discussed previously, working memory abilities have more of an effect at higher levels, rather than lower levels, of ADHD symptoms. Specifically, results showed that the effect of working memory on *competitive* behaviours was most apparent when there were more ADHD symptoms, so that better working memory seems to alleviate some of the social difficulties typically manifested at higher levels of ADHD. Behaving in a less competitive manner would not be as complex a social endeavour as behaving collaboratively (i.e., coordinating one's own goals and behaviours with another's); consequently, one may not need to be functioning at "optimal" levels (low ADHD symptoms and high EF skills). This may be why working memory has an effect on competitive behaviours, in particular at higher levels of ADHD. On another note, there is also much research indicating that inhibitory control deficits are much more prevalent in ADHD; however, there is mixed evidence regarding other EF components and whether they are unique to ADHD or lead to the behavioural manifestations of

ADHD (Brocki et al., 2007; Thorell & Wahlstedt, 2006; Crosbie et al., 2008). Other EF components may occur at varying levels in those higher on ADHD symptoms and in fact serve to alleviate some of the behavioural manifestations of ADHD (Willcutt et al., 2005).

Finally, while EFs did not seem to uniquely interact with ODD/CD symptoms to affect social behaviour, it was found that older children with more ODD/CD symptoms had partners who exhibited more competitive behaviours. These effects were significant even while controlling for ADHD symptoms.

It is noteworthy that symptoms of ODD/CD were related to older children's partners displaying more competitive behaviours. Interestingly, children did not seem to react competitively to children who exhibited ADHD symptoms (when controlling for ODD/CD symptoms); however, they did seem to react competitively to children who exhibited specifically ODD/CD symptoms (when controlling for ADHD symptoms). It is possible that children with ODD/CD symptoms were perceived by others in a more negative fashion (i.e., as more competitive or hostile), and thus, children reacted more negatively towards them. That is, although there was not a significant relationship between children's ODD/CD symptoms and their own competitive behaviours in this study, partners could be behaving based on their knowledge and past experience with a child high on ODD/CD symptoms. Thus, older children may differentiate between children who are seen as intentionally aggressive (i.e., children with ODD/CD symptoms) versus children who exhibit social deficits due to lack of ability (i.e., children with ADHD symptoms). Past research indicates that children with ODD/CD, compared to ADHD, behave in more hostile ways towards peers, which could lead to more negative reactions from their peers (Frankel & Feinberg, 2002). These findings would suggest that there is

a key distinction between ADHD and ODD/CD, particularly in how other children view and interact with these children.

### **Implications and Future Directions**

Poor social adjustment in childhood has been shown to have an impact on later peer acceptance and functioning (e.g., internalizing and externalizing problems, academic difficulties, and adult criminality; Hymel et al., 1990; Johnson, Ironsmith, Snow & Poteat, 2000; Parker & Asher, 1987). As such, it is vital to understand how to prevent or limit these early poor social experiences. Findings from this dissertation highlight the effects of EFs, ToM, and language skills and the interaction of EFs with ADHD symptoms to influence social behaviour.

These results have interesting implications for theoretical accounts of social functioning, that is, the factors involved in the development of effective social interactions. For instance, Nilsen and Fecicia (2011) present a model of communicative perspective-taking (i.e., attending to and using information about a person's knowledge state to guide one's communication with that person), which could be extended to social interactions in general, wherein ToM (mentalizing abilities) and EFs (cognitive abilities) play a key role. Results from this dissertation support the proposed role of ToM and EF skills in social functioning. Furthermore, findings support the notion that children's characteristics (i.e., cognitive skills and presence of externalizing symptoms) may influence the quality of interactions they have (e.g., how social partners react towards them), which may in turn affect future skill development. Results from this dissertation may also serve to expand or further specify this model of socio-communicative development. For instance, it seems that the specific cognitive skills related to effective social interactions depend on the developmental stage/age of a child. Specifically, while younger children may rely heavily on ToM skills to guide socially appropriate behaviour; older children

rely on both ToM and EF (i.e., planning skills) to guide their behaviour. In addition, not currently included in the model proposed by Nilsen and Fecicia, it is important to note that the presence of externalizing symptoms is another important factor that influences (and is influenced by) social interactions.

Results from this study also have important implications for early intervention or prevention programs. Specifically, the results regarding the effect of EF components and the interaction effect of EF with ADHD symptoms on social skills suggest that intervening to improve EFs (e.g., inhibitory control, working memory) in children with and without ADHD symptoms may be especially helpful in improving children's social functioning. Because these effects seem to occur later in childhood, early childhood would be a time to identify children who are 'at risk' in order to improve a child's EF with the hopes that this would improve their later social functioning. Results from the current study also suggest that while improving inhibitory control skills may not necessarily provide much effect for those higher on ADHD symptoms, it would prove more useful for those with fewer ADHD symptoms. On the other hand, improvements in working memory may be particularly effective for improving social skills in those higher on ADHD symptoms. In recent years, there has been an increased effort to determine whether EFs can be enhanced through focused interventions. Studies have conducted EF training in a number of ways, such as providing practice with task-switching (i.e., switching between two simple cognitive tasks), working memory and inhibition training (e.g., computerized training), neurostimulation or neurofeedback, or specific curricula (e.g., Tools of the Mind curriculum) (for reviews, see Diamond & Lee, 2011; Enriquez-Geppert, Huster, & Herrmann, 2013). Several studies have shown that EF training does indeed lead to improvements in EFs (e.g., inhibitory control and working memory) and academic performance (e.g., spelling,

mental math), even in children with ADHD (e.g., Dowsett & Livesey, 2000; Enriquez-Geppert et al., 2013; Karbach & Kray, 2009; Kray, Karbach, Haenig, & Freitag, 2012; Malekpour & Aghababaei, 2013). To this author's knowledge, most research has not yet looked at the impact of EF training specifically on social skills; however, one study examining the use of martial arts training to improve self-regulation found that this training led to increased prosocial behaviour (Lakes & Hoyt, 2004). Demonstrating an alternate pathway, research has shown that early social interactions may have an impact on EF development (Moriguchi, 2014). Consequently, it may also be important to attend to children's early social experiences and activities as a way to improve later EF skills, and perhaps, later social skills (Diamond & Lee, 2011; Moriguchi, 2014).

Findings from this dissertation also suggest that ToM skills are particularly important in guiding both younger and older children's and their partners' socially appropriate behaviours; thus, early identification of children experiencing ToM difficulties may be especially important in order to target at-risk children. Specifically, ToM training may be particularly helpful for children in order to improve their social functioning (Allen & Kinsey, 2013). ToM training has typically focused on training in false-belief understanding, perspective shifting, dual representation or pretence (Kloo & Perner, 2008; Moses & Tahiroglu, 2010). Although some studies have found that ToM training leads to increases in EF but not ToM, other studies show that ToM and even EF training can lead to increases in ToM (Allen & Kinsey, 2013; Moses & Tahiroglu, 2010). Thus, training ToM and/or EF appears to be a fruitful area of exploration for future research with the goal of improving social functioning. A direction for future studies would be to conduct EF and ToM training with at-risk children and study the long-term effects on social functioning.

On another note, there were a number of findings suggesting that children's characteristics (i.e., cognitive skills and symptom profiles) elicited specific behaviours from their partners, which has some interesting implications for partner-work and how some pairings may be more or less beneficial for children's social functioning. Pairing of children may be particularly useful to consider in school settings where children are involved in frequent partner- and group-work. For example, pairing a child with another child who has more advanced cognitive abilities (e.g., ToM, verbal skills) may elicit less competitive behaviour from the other child. On the other hand, pairing an older child with a peer who has better inhibitory control and fewer ADHD symptoms may elicit more collaborative behaviours from another child who may not typically demonstrate as many collaborative behaviours. When considering these pairings, one would also need to consider the age of children, as the cognitive abilities seem to have different effects on partner's behaviours depending if a child is younger or older. In the end, children may learn from their more socially and cognitive skilled partners to behave less competitively and more collaboratively. Although speculative, it may be the case that this demonstration of more socially skilled behaviours would translate to children's other social interactions. As such, an interesting area for future research would be to investigate whether the influence of a child with better cognitive and social skills on another child's functioning would generalize to that other child's social interactions with others. In contrast, it is interesting that this type of pairing may be less beneficial when a child is struggling in a specific way, that is, exhibiting ODD/CD symptoms. Specifically, this study shows that older children in general tend to react competitively to these types of characteristics. Consequently, it would be important, when assigning children to pair- or group-work, to consider the relative benefit or consequences a pairing would have on each child.

Related, it may be prudent to try to create more understanding and tolerance in other children for those who struggle with ODD/CD symptoms. On one hand, it is not surprising that children react more negatively to children with ODD/CD, given that adults often become caught in a cycle with these children that does not bring out the best behaviours in either (Greene, Ablon, & Goring, 2003). However, a relatively new line of thought views children with ODD/CD difficulties as having skills deficits in emotion regulation, frustration tolerance, and problem solving skills, instead of seeing aggressive behaviours as hostile and intentional (Greene, 2011; Greene et al., 2003; Greene et al., 2004). New research suggests that having adults tailor their own behaviour to be more compatible with these children's characteristics and engaging in "collaborative problem solving" with them will lead to improvements in these children's behaviour (Greene et al., 2004). Thus, it may be useful for children in general to also understand the behaviours typically manifested by children with ODD/CD difficulties in a different way, in order to counteract potentially biased preconceptions about a child with ODD/CD difficulties. It would be interesting to see whether children who are more cognitively and socially advanced do react competitively to peers with these struggles and if they could be taught to choose a more neutral way to react and to problem-solve with these children. Changing the reactions of other children could lead to improvements in behaviour from children with ODD/CD because having more positive interactions with other children may serve to undermine some of the negative cognitive interpretations these children have regarding social interactions (e.g., hostile attribution biases; Green et al., 2004). In the end, children who are more cognitively and socially skilled may have a positive influence, even on the behaviours of children with ODD/CD symptoms.

## **Limitations**

It is important to note again some limitations of this dissertation research. First, only a limited number of tasks were used to assess EF components, ToM, and verbal skills, which may have influenced the relationships that could be found between these cognitive skills and social behaviour. Second, the nature of children's relationships before participating with a partner in the dyadic task was not controlled for. This may be important to control for because children who are good friends may behave differently together than children who are not friends. Third, the reliability between coders for the competitive behaviours that occurred during the cooperative social task was shown to be somewhat unreliable and very few of these types of behaviours occurred in both age groups. The unreliability of the coding and the skewness of this variable may have affected analyses using this variable. In short, results regarding the competitive behaviours should be interpreted cautiously; however, using the bootstrap analysis to further test my results was a more robust way of dealing with this skewed variable. Fourth, the effect sizes of planning, theory of mind and verbal skills on competitive and cooperative behaviours was modest (e.g., 3% of the proportion of variance in cooperative behaviours for older children was explained by theory of mind and 14% of the proportion of variance in competitive behaviour for younger children was explained by theory of mind). These modest effect sizes may limit the real-world implications that can be drawn; however, these effect sizes are not surprising given that past research highlights the difficulty of predicting behaviour on one occasion with one type of task (e.g., Epstein, 1979). These relationships may be better studied by averaging children's social behaviours over a number of social situations, thus allowing for more stable predictions of children's behaviours. Fifth, participants in this study were primarily from a typically developing population and the presence of ADHD and ODD/CD symptoms was

relatively low compared to a clinical sample. Consequently, the range at the more extreme end of ADHD and ODD/CD symptoms was restricted and results from this study should be interpreted with caution when generalizing to a clinical population. Future studies could be conducted with a clinical population using a more comprehensive battery of EF components, ToM, and verbal abilities and averaging behaviour over a number of social situations.

## **Conclusion**

In conclusion, this study is the first to date to use a dyadic model to control for partner and actor effects when investigating different components of EF, ToM and verbal skills, as well as how EF components interact with symptoms of ADHD and ODD/CD to affect social behaviours at different ages. It was found that different cognitive skills (i.e., planning, ToM, and verbal skills) were indeed utilized in different ways by younger versus older children to guide their social behaviours. It also seems that EFs serve an important function in moderating symptoms of ADHD in older children to improve social skill and that increases in ODD/CD symptoms have negative effects on social partners' behaviours. This study adds to the current literature by providing a better understanding of how children of different ages draw upon cognitive functions in distinct ways to guide their social behaviour. These findings imply a specific developmental trajectory for each cognitive skill (e.g., planning, ToM) and how children are able to utilize a skill more effectively as it develops. In addition, results suggest it is important to look at children's social competence using different methods in order to gain a more complete picture of how EFs and other cognitive abilities play a role in socially competent behaviour. By looking directly at social behaviours and using dyadic data analyses, this study was able to provide a clearer picture of how specific characteristics of children have an influence on the social behaviours of other children with whom they are interacting. Theoretical

implications from this study are that cognitive skills are particularly important in guiding social interactions and children's characteristics may play a key role in influencing the quantity and quality of interactions they have with others. Furthermore, models regarding social development should take into account the developmental stage of a child in understanding what cognitive skills are important for social interactions, as well as externalizing symptoms and how they influence social development. In turn, clinical implications are that it may be particularly helpful to intervene at an early age with EF and/or ToM training for children at-risk of social difficulties or presenting with specific clinical symptoms (i.e., ADHD). It may also prove important to attend to how children are paired together during partner or group work and how this may affect later cognitive and social skills. In sum, this dissertation is informative for future work investigating the relationships between cognitive skills, ADHD, ODD/CD, and social development and the long-term effects of EF and/or ToM training, as well as partner-work, on later social skills and externalizing symptoms.

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Table 1

*Younger Group Ethnicity and Parent Education Level as a Percentage of the Sample*

	Child ( <i>n</i> = 117)	Mother ( <i>n</i> = 130)	Father ( <i>n</i> = 126)
Ethnicity			
White/European	73.1		
Asian	7.7		
Eastern European	3.8		
Black	0		
Latin American	2.3		
Middle Eastern	0.8		
Aboriginal/Native American	0		
Other	2.3		
Education level completed			
8 <sup>th</sup> grade or less		0.8	0.8
High-school		11.5	17.7
College		41.5	46.2
Some university		3.8	3.8
Professional degree		6.9	1.5
University undergraduate degree		26.9	16.2
University graduate degree		8.5	10.8

Table 2

*Older Group Ethnicity and Parent Education Level as a Percentage of the Sample*

	Child ( <i>n</i> = 115)	Mother ( <i>n</i> = 117)	Father ( <i>n</i> = 114)
Ethnicity			
White/European	62.7		
Asian	11.0		
Eastern European	7.6		
Black	2.5		
Latin American	2.5		
Middle Eastern	0		
Aboriginal/Native American	1.7		
Other	9.3		
Education level completed			
8 <sup>th</sup> grade or less		0	0
High-school		19.5	30.5
College		41.5	35.6
Some university		4.2	5.1
Professional degree		9.3	3.4
University undergraduate degree		16.9	12.7
University graduate degree		7.6	9.3

Table 3

*Means (Standard Deviations) of the Cognitive Tasks for the Younger and Older Groups*

Cognitive Task	Younger Group		Older Group	
	<i>n</i>	<i>M (SD)</i>	<i>n</i>	<i>M (SD)</i>
No-Go False Alarm Rate	121	0.21 (0.15)	113	0.13 (0.10)
Finger Windows	130	7.72 (3.98)	118	12.80 (3.89)
Tower	130	10.52 (3.08)	118	12.89 (1.97)
ToM	130	13.08 (3.80)	118	18.84 (2.93)
Vocabulary	130	7.68 (2.77)	118	12.25 (2.45)

*Note.* No-Go False Alarm Rate = proportion out of 1; Finger Windows = total score out of 24; Tower = total score out of 20; ToM = total score out of 22; Vocabulary = total score out of 19.

Table 4

*Younger Group Bivariate Correlations between the No-Go False Alarm Rate, Finger Windows, Tower, ToM, Vocabulary, and Age*

	No-Go False Alarm Rate	Finger Windows	Tower	ToM	Vocabulary
No-Go False Alarm Rate	--	--	--	--	--
Finger Windows	-.13	--	--	--	--
Tower	-.07	.42***	--	--	--
ToM	-.17	.51***	.43***	--	--
Vocabulary	.04	.39***	.28***	.46***	--
Age	-.16	.60***	.41***	.51***	.41***

*Note.* No-Go False Alarm Rate = proportion out of 1; Finger Windows = total score out of 24; Tower = total score out of 20; ToM = total score out of 22; Vocabulary = total score out of 19; Age = Age in months.

\* $p < .05$  (2-tailed). \*\* $p < .01$  (2-tailed). \*\*\* $p < .001$  (2-tailed).

Table 5

*Older Group Bivariate Correlations between the No-Go False Alarm Rate, Finger Windows, Tower, ToM, Vocabulary, and Age*

	No-Go False Alarm Rate	Finger Windows	Tower	ToM	Vocabulary
No-Go False Alarm Rate	--	--	--	--	--
Finger Windows	-.13	--	--	--	--
Tower	-.12	.14	--	--	--
ToM	.00	.20*	.15	--	--
Vocabulary	-.13	.27**	.14	.36***	--
Age	-.12	.07	.21*	.24*	.22*

*Note.* No-Go False Alarm Rate = proportion out of 1; Finger Windows = total score out of 24; Tower = total score out of 20; ToM = total score out of 22; Vocabulary = total score out of 19; Age = Age in months.

\* $p < .05$  (2-tailed). \*\* $p < .01$  (2-tailed). \*\*\* $p < .001$  (2-tailed).

Table 6

*Means (Standard Deviations) of the Parent Ratings of Social Skills for the Younger and Older Groups*

Social Skill Ratings	Younger		Older	
	<i>n</i>	<i>M (SD)</i>	<i>n</i>	<i>M (SD)</i>
Total Social	121	17.01 (2.33)	117	16.91 (2.63)
Prosocial	125	8.57 (1.42)	117	8.85 (1.35)
Peer Problems	125	8.37 (1.55)	117	8.06 (1.87)

*Note.* Total Social = total score out of 20 where a higher score is better social skills overall; Prosocial = total score out of 10 where a higher score is more prosocial behaviours; Peer Problems = total score out of 10 where a higher score is fewer peer problems.

Table 7

*Means (Standard Deviations) of the Cooperative, Competitive, and Neutral Behaviours for the Younger and Older Groups*

Total Behaviours	Younger	Older	Proportion Behaviours	Younger	Older
	<i>M (SD)</i>	<i>M (SD)</i>		<i>M (SD)</i>	<i>M (SD)</i>
Cooperative	1.45 (8.39)	8.14 (18.10)	Proportion Cooperative	0.02 (0.10)	0.10 (0.19)
Competitive	0.85 (2.90)	0.28 (0.97)	Proportion Competitive	0.02 (0.05)	0.01 (0.01)
Neutral	50.87 (12.42)	59.44 (15.81)	Proportion Neutral	0.96 (0.11)	0.90 (0.19)

*Note.*  $N = 130$  (Younger group) and  $116$  (Older group); Cooperative = total number of cooperative behaviours; Competitive = total number of competitive behaviours; Neutral = total number of neutral behaviours; Proportion Cooperative = total number of cooperative behaviours divided by the total number of behaviours; Proportion Competitive = total number of competitive behaviours divided by the total number of behaviours; Proportion Neutral = total number of neutral behaviours divided by the total number of behaviours.

Table 8

*Younger Group Bivariate Correlations between Each Pairs' Behaviours in the Cooperative Social Task*

	Proportion Cooperative B	Proportion Competitive B	Proportion Neutral B
Proportion Cooperative A	.88***	-.05	-.84***
Proportion Competitive A	-.07	.78***	-.15
Proportion Neutral A	-.61***	-.51***	.74***

*Note.*  $N = 65$ ; A = partner A; B = partner B; Proportion Cooperative = total number of cooperative behaviours divided by the total number of behaviours; Proportion Competitive = total number of competitive behaviours divided by the total number of behaviours; Proportion Neutral = total number of neutral behaviours divided by the total number of behaviours.

\* $p < .05$  (2-tailed). \*\*  $p < .01$  (2-tailed). \*\*\* $p < .001$  (2-tailed).

Table 9

*Older Group Bivariate Correlations between Each Pairs' Behaviours in the Cooperative Social Task*

	Proportion Cooperative B	Proportion Competitive B	Proportion Neutral B
Proportion Cooperative A	.83***	-.07	-.82***
Proportion Competitive A	.03	.47***	-.07
Proportion Neutral A	-.82***	.03	.82***

*Note.*  $N = 58$ ; A = partner A; B = partner B; Proportion Cooperative = total number of cooperative behaviours divided by the total number of behaviours; Proportion Competitive = total number of competitive behaviours divided by the total number of behaviours; Proportion Neutral = total number of neutral behaviours divided by the total number of behaviours.

\* $p < .05$  (2-tailed). \*\*  $p < .01$  (2-tailed). \*\*\* $p < .001$  (2-tailed).

Table 10

*Younger Group Bivariate and Partial Correlations between Cognitive Tasks and Parent Ratings of Social Skills*

	Total Social
No-Go false alarm rate	-.10 (-.05)
Finger Windows	.14 (.00)
Tower	.20* (.14)
ToM	.22* (.23*)
Vocabulary	-.01 (-.08)

*Note.* Partial correlations controlling for the other executive functions, ToM, Vocabulary and Age are shown in parentheses. Total Social = higher score is better social skills overall; No-Go False Alarm Rate = proportion out of 1; Finger Windows = total score out of 24; Tower = total score out of 20; ToM = total score out of 22; Vocabulary = total score out of 19.

\* $p < .05$  (2-tailed). \*\*  $p < .01$  (2-tailed). \*\*\* $p < .001$  (2-tailed).

Table 11

*Older Group Bivariate and Partial Correlations between Cognitive Tasks and Parent Ratings of Social Skills*

	Total Social
No-Go false alarm rate	-.17 (-.17)
Finger Windows	.06 (.01)
Tower	.05 (.03)
ToM	.11 (.10)
Vocabulary	.11 (.07)

*Note.* Partial correlations controlling for the other executive functions, ToM, Vocabulary and Age are shown in parentheses. Total Social = higher score is better social skills overall; No-Go False Alarm Rate = proportion out of 1; Finger Windows = total score out of 24; Tower = total score out of 20; ToM = total score out of 22; Vocabulary = total score out of 19.

\* $p < .05$  (2-tailed). \*\*  $p < .01$  (2-tailed). \*\*\* $p < .001$  (2-tailed).

Table 12

*Means (Standard Deviations) of the Parent Ratings of Symptoms of ADHD and ODD/CD for the Younger and Older Groups*

Symptom Ratings	Younger		Older	
	<i>n</i>	<i>M (SD)</i>	<i>n</i>	<i>M (SD)</i>
ADHD Inattention	111	5.96 (5.31)	106	6.80 (5.91)
ADHD Hyperactive/Impulsive	105	5.97 (5.32)	99	4.04 (4.44)
ADHD Total	102	11.57 (9.66)	96	10.71 (9.61)
ODD	113	4.70 (4.81)	108	4.88 (4.73)
CD	113	0.54 (1.84)	105	0.46 (1.20)
ODD/CD Total	113	5.24 (6.16)	105	5.44 (5.61)

*Note.* ADHD Inattention = total score out of 27; ADHD Hyperactive/Impulsive = total score out of 27; ADHD Total = total score out of 54; ODD = Oppositional Defiant Disorder total score out of 24; CD = Conduct Disorder total score out of 15; ODD/CD = total score out of 39.

Table 13

*Younger Group Bivariate and Partial Correlations between Cognitive Tasks and Parent Ratings of Symptoms*

	ADHD Total	ODD/CD
No-Go false alarm rate	-.02 (.00)	-.02 (.00)
Finger Windows	-.11 (-.10)	-.12 (-.02)
Tower	.01 (-.08)	.02 (.10)

*Note.* Partial correlations controlling for the other symptom profile and age are shown in parentheses. ADHD Total = Total score on symptoms of inattention and hyperactivity/impulsivity out of 54; ODD/CD = Total score on symptoms of oppositional defiant disorder and conduct disorder out of 39; No-Go False Alarm Rate = proportion out of 1; Finger Windows = total score out of 24; Tower = total score out of 20.

\* $p < .05$  (2-tailed). \*\*  $p < .01$  (2-tailed). \*\*\* $p < .001$  (2-tailed).

Table 14

*Older Group Bivariate and Partial Correlations between Cognitive Tasks and Parent Ratings of Symptoms*

	ADHD Total	ODD/CD
No-Go false alarm rate	.17 (-.02)	.24* (.19)
Finger Windows	-.17 (-.15)	-.10 (.04)
Tower	.07 (.06)	.01 (-.03)

*Note.* Partial correlations controlling for the other symptom profile and age are shown in parentheses. ADHD Total = Total score on symptoms of inattention and hyperactivity/impulsivity out of 54; ODD/CD = Total score on symptoms of oppositional defiant disorder and conduct disorder out of 39; No-Go False Alarm Rate = proportion out of 1; Finger Windows = total score out of 24; Tower = total score out of 20.  
 \* $p < .05$  (2-tailed). \*\*  $p < .01$  (2-tailed). \*\*\* $p < .001$  (2-tailed).

Table 15

*Younger Group Bivariate Correlations between Parent Ratings of Social Skills and Ratings of Symptoms*

	ADHD Total	ODD/CD
Total Social	-.44***	-.54***
Total Prosocial	-.39***	-.41***
Total Peer problems	-.29**	-.43***

*Note.* ADHD Total = Total score on symptoms of inattention and hyperactivity/impulsivity out of 54; ODD/CD = Total score on symptoms of oppositional defiant disorder and conduct disorder out of 39; Total Social = higher score is better social skills overall; Total Prosocial = higher score is more prosocial behaviours; Total Peer problems = higher score is fewer peer problems.

\* $p < .05$  (2-tailed). \*\*  $p < .01$  (2-tailed). \*\*\* $p < .001$  (2-tailed).

Table 16

*Older Group Bivariate Correlations between Parent Ratings of Social Skills and Ratings of Symptoms*

	ADHD Total	ODD/CD
Total Social	-.50***	-.51***
Total Prosocial	-.40***	-.43***
Total Peer problems	-.43***	-.41***

*Note.* ADHD Total = Total score on symptoms of inattention and hyperactivity/impulsivity out of 54; ODD/CD = Total score on symptoms of oppositional defiant disorder and conduct disorder out of 39; Total Social = higher score is better social skills overall; Total Prosocial = higher score is more prosocial behaviours; Total Peer problems = higher score is fewer peer problems.

\* $p < .05$  (2-tailed). \*\*  $p < .01$  (2-tailed). \*\*\* $p < .001$  (2-tailed).

Table 17

*Younger Group Bivariate Correlations between Social Behaviours during the Cooperative Social Task and Parent Ratings of Symptoms*

	ADHD Total	ODD/CD
Proportion Cooperative	.01	-.08
Proportion Competitive	.10	.13
Proportion Neutral	-.05	.01

*Note.* ADHD Total = Total score on symptoms of inattention and hyperactivity/impulsivity out of 54; ODD/CD = Total score on symptoms of oppositional defiant disorder and conduct disorder out of 39; Proportion Cooperative = total number of cooperative behaviours divided by the total number of behaviours; Proportion Competitive = total number of competitive behaviours divided by the total number of behaviours; Proportion Neutral = total number of neutral behaviours divided by the total number of behaviours.

\* $p < .05$  (2-tailed). \*\*  $p < .01$  (2-tailed). \*\*\* $p < .001$  (2-tailed).

Table 18

*Older Group Bivariate Correlations between Social Behaviours during the Cooperative Social Task and Parent Ratings of Symptoms*

	ADHD Total	ODD/CD
Proportion Cooperative	-.03	-.07
Proportion Competitive	.25*	.17
Proportion Neutral	.01	.06

*Note.* ADHD Total = Total score on symptoms of inattention and hyperactivity/impulsivity out of 54; ODD/CD = Total score on symptoms of oppositional defiant disorder and conduct disorder out of 39; Proportion Cooperative = total number of cooperative behaviours divided by the total number of behaviours; Proportion Competitive = total number of competitive behaviours divided by the total number of behaviours; Proportion Neutral = total number of neutral behaviours divided by the total number of behaviours.

\* $p < .05$  (2-tailed). \*\*  $p < .01$  (2-tailed). \*\*\* $p < .001$  (2-tailed).

Figure 1. Social Block Task Materials.



Figure 1. This includes two 13" X 13" wooden frames consisting of a pattern of 100 1" X 1" coloured squares, 150 1" X 1" wooden blocks, a wooden frame model with 30 blocks as a demo, a demo point system scoreboard, a scoreboard, and a timer.

Figure 2. Model for the Relationship between Planning, Theory of Mind, and Vocabulary and the Competitive Behaviours in the Cooperative Social Block Task.

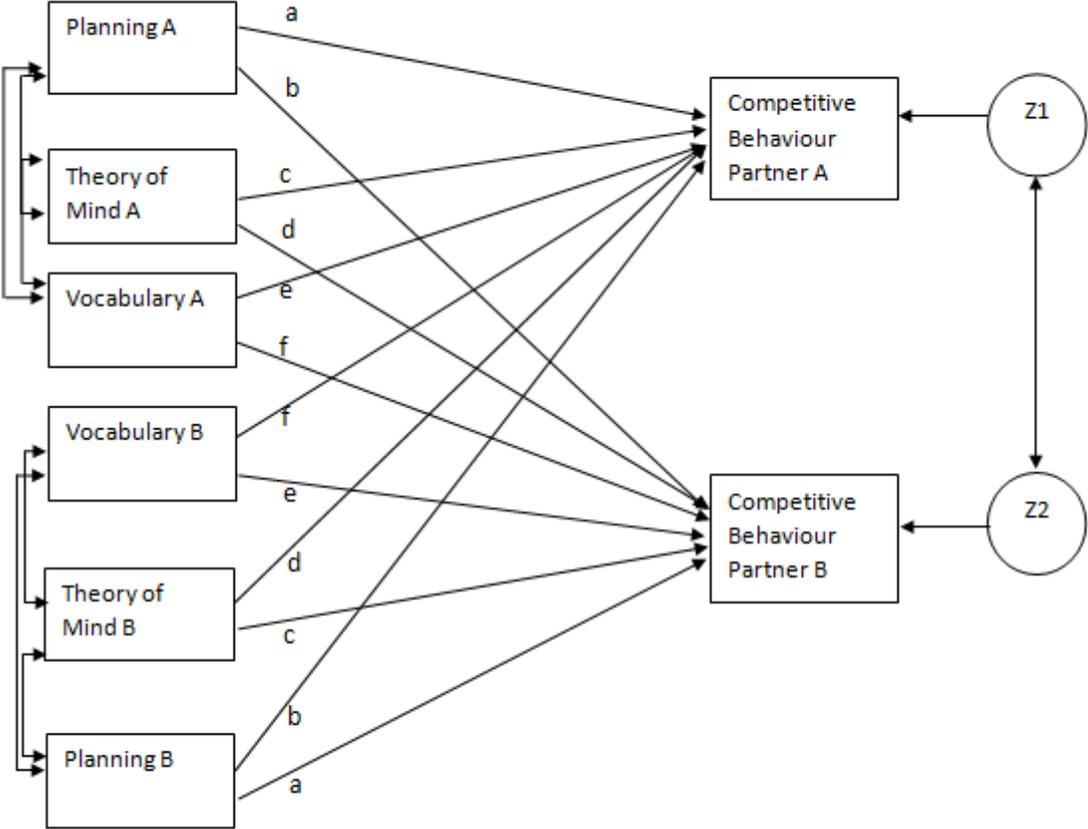
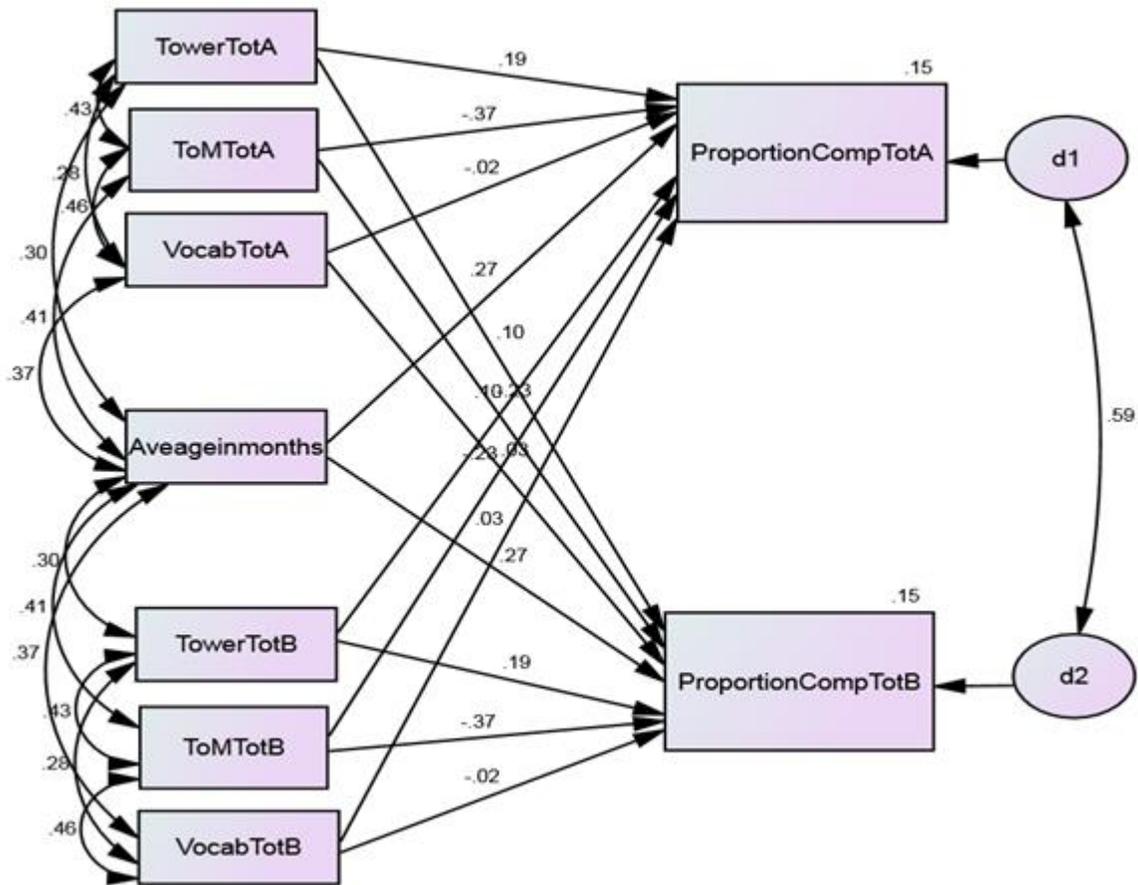


Figure 3. Model for the Younger Group: Relationship between Planning, Theory of Mind, and Vocabulary and the Competitive Behaviours in the Cooperative Social Block Task.



*Note.* TowerTot = planning; ToMTot = theory of mind; VocabTot = vocabulary; Aveageinmonths = average age in months; ProportionCompTot = proportion of competitive behaviour. All parameter estimates are in standardized form.

Figure 4. Model for the Relationship between Inhibitory Control, ADHD, the Interaction Term, and Total Social Skills.

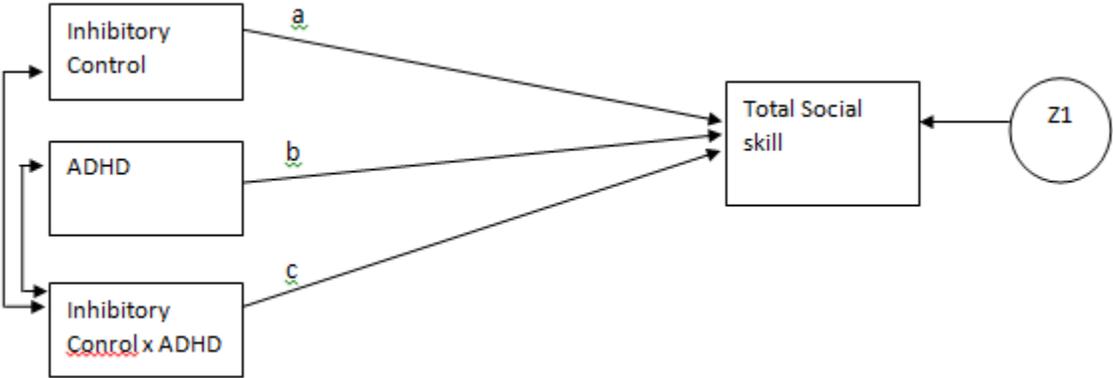


Figure 5. Interaction Effect of Working Memory and ADHD Symptoms on Children's Total Social Skills.

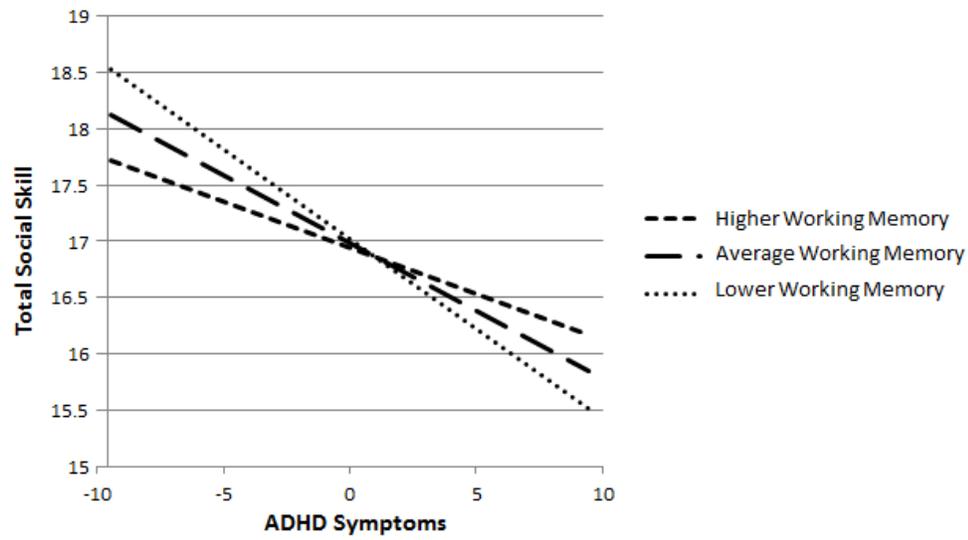


Figure 6. Interaction Effect of Working Memory and ADHD Symptoms on the Percentage of Children's Own Competitive Behaviours.

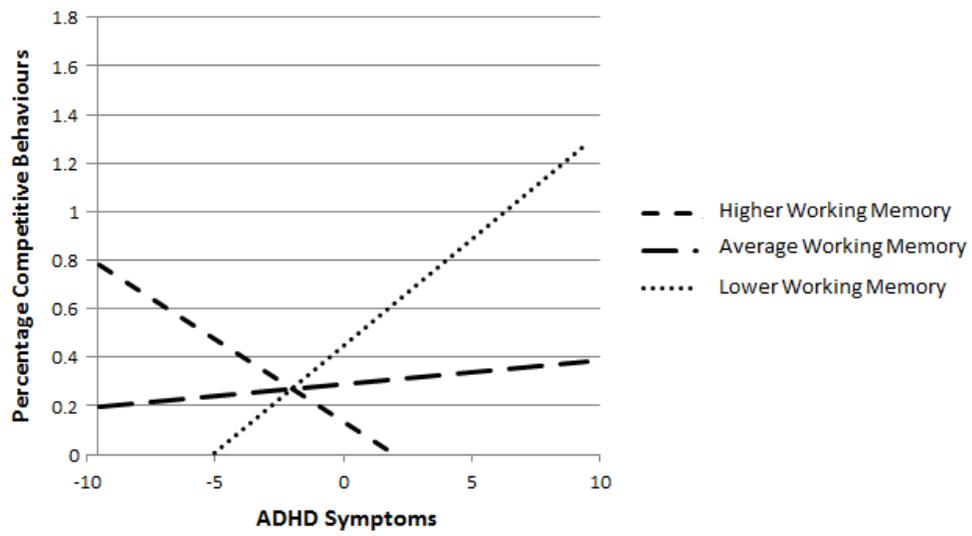


Figure 7. Interaction effect of Inhibitory Control and ADHD Symptoms on the Percentage of Children's Own and Partners' Cooperative Behaviours.

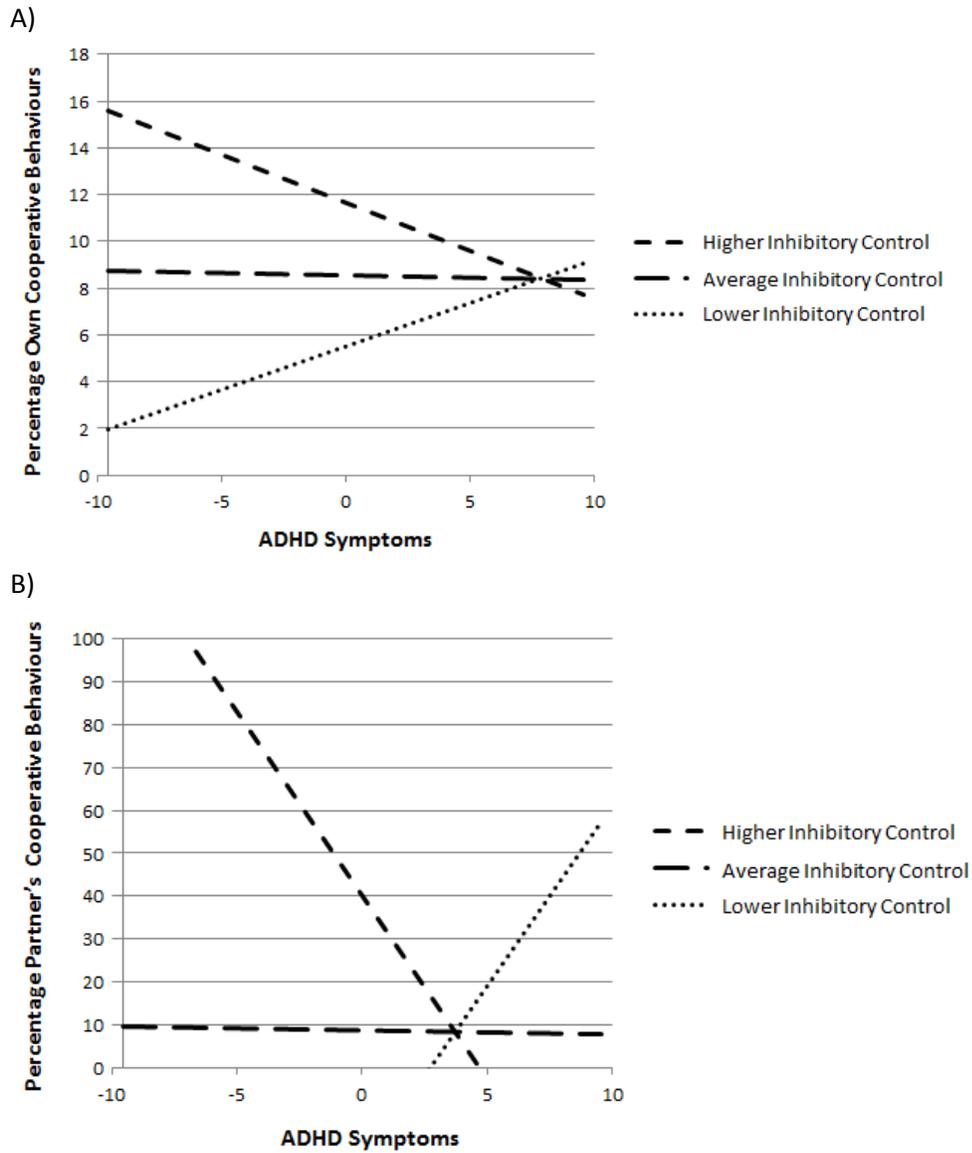
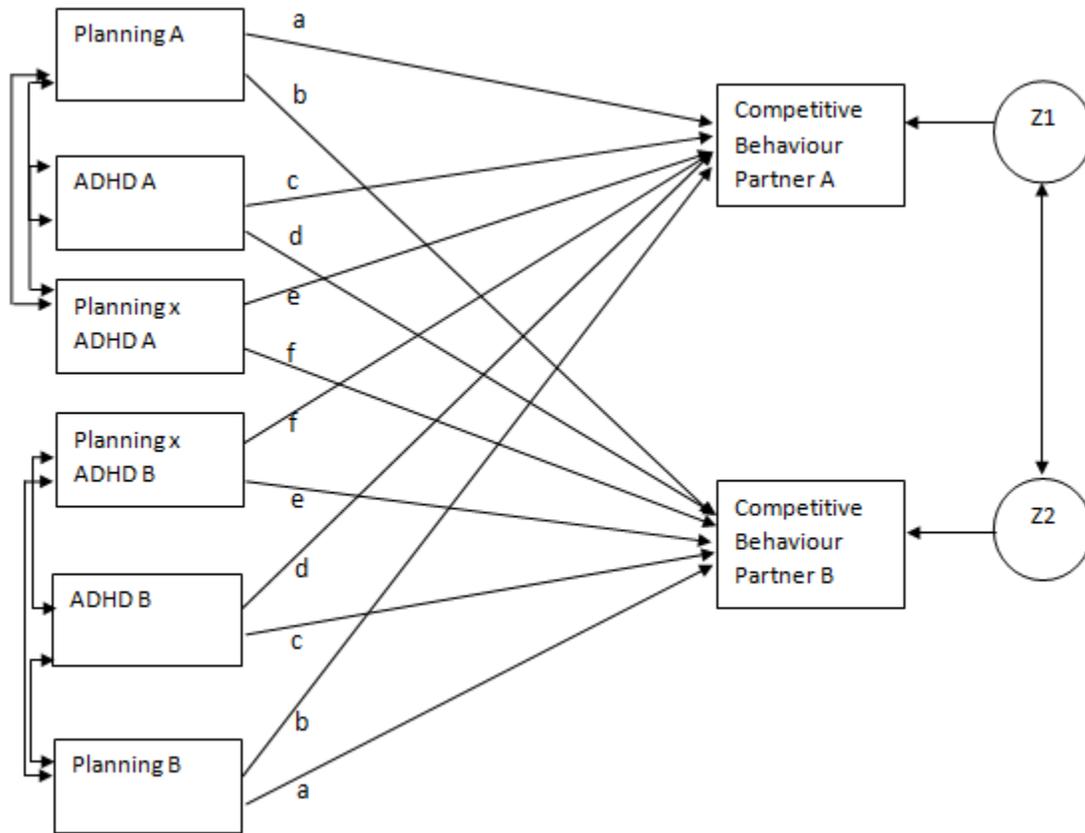


Figure 8. Model for the Relationship between Planning, ADHD, the Interaction Term, and Competitive Behaviours in the Cooperative Social Block Task



## Appendices

### Appendix A

#### Demographic Questionnaire

We are interested in gathering more information about your child and his/her daily environment. Please complete the following questions:

- I am the child's: (please check one)
  - Mother
  - Father
  - Guardian
  - Other: \_\_\_\_\_
  
- Does your child have any siblings? (please check one)
  - Yes
  - NoIf Yes, how many? \_\_\_\_\_ Please specify their ages: \_\_\_\_\_
  
- What is your child's ethnic background? \_\_\_\_\_
  
- What is the primary language spoken in your home? \_\_\_\_\_
  
- Has your child spoken English from birth? (please check one)  Yes  No  
If **NO**, at what age (in months) was your child first exposed to English: \_\_\_\_\_ months
  
- Please list any other languages are spoken in your home?
  - i. \_\_\_\_\_
  - ii. \_\_\_\_\_
  - iii. \_\_\_\_\_
  - iv. \_\_\_\_\_
  
- How many adults are there in your household? \_\_\_\_\_
  
- Outside of time spent at school or preschool, please describe the different forms of childcare your child receives: (check all that apply)
  - Stays at home with parent/relative: relation: \_\_\_\_\_  
How many days per week (including weekends)? \_\_\_\_\_
  - Stays at home with paid caregiver (e.g., "nanny")  
How many days per week (including weekends)? \_\_\_\_\_
  - Daycare  
How many days per week (including weekends)? \_\_\_\_\_
  
- Is your child colour –blind? (please check one)
  - Yes

- No
- Don't Know

If yes, please specify: \_\_\_\_\_

- Has your child ever been diagnosed with Attention-Deficit Hyperactivity Disorder (ADHD), Oppositional Defiant Disorder (ODD) or any other disorder?
  - Yes
  - No
  - Queried, but not formally diagnosed

If yes, please specify:

\_\_\_\_\_

- Is your child currently on any medication to manage emotional or behavioural issues?  
If yes, please indicate:

\_\_\_\_\_

- What is the highest level of education **you** have? (please check one)
  - Secondary school
  - Some college
  - College diploma or degree
  - Some university
  - University degree (undergraduate)
  - Graduate degree (M.A., M.Sc., Ph.D.)
  - Professional degree
  
- What is the highest level of education your child's **other parent** has? (please check one)
  - Secondary school
  - Some college
  - College diploma or degree
  - Some university
  - University degree (undergraduate)
  - Graduate degree (M.A., M.Sc., Ph.D.)
  - Professional degree

## Appendix B

### Interactive Cooperative Block Game Instructions

*We are having a contest to see how many points two people working together can earn by finishing these patterns of colours with these wooden blocks.*

*You want to work together to earn the most points possible for your team! First, let's come up with a team name for you guys. What do you want your team name to be? Decide with each other and then I'll write it on the scoreboard (put their name up on the scoreboard for them to see).*

*Okay, here are the blocks (uncover the blocks laid out face-down on the table) for you to use to finish the coloured patterns on your wooden models. Your job [child's name] is to put the blocks in the right spot on this model in front of you (point to the model in front of the child) and your job [child's name] is to put the blocks in the right spot for this model in front of you (point to the model in front of the child). But, you're allowed to help each other with each other's models if you want. Remember you want your team to earn a lot of points.*

*You will have 3 minutes to complete as many blocks as you can.*

*For each block you finish, you will get a point. If you finish all the blocks for one colour, you will get extra points, 10 bonus points. If you don't finish all the blocks for one colour, you will get fewer points, no bonus points.*

*For example, let's look at this model someone finished. You can see they did one green coloured block (show children the demo for the point system), so they would get 1 point for the 1 block.*

*For the blue colour, they finished 1, 2, 3, 4, 5, 6, 7, 8, 9 blocks, so they would get 9 points for the 9 blocks. But, because they didn't finish the whole blue colour, they wouldn't get any bonus points.*

*Now, look at the yellow coloured blocks. For the yellow colour, they finished all 10 blocks like you see here, so they would get 10 points for the 10 blocks, **PLUS** 10 bonus points because they finished the whole yellow colour. So, they would get 20 points altogether for the yellow!*

*Same with the pink coloured blocks, you can see they finished all 10 pink blocks so they would get 10 points for the 10 blocks, **PLUS** 10 bonus points because they finished the whole pink colour. So they would get 20 points altogether for the pink!*

*So, if you had one more blue block here (point to spot), how many points would you get all together for the blue blocks?*

*Just so you know, there are not enough blocks here for both of you to finish all the colours on both of your models.*

*The only rules are that you must keep the blocks face down like they are right now, unless you or you are using the piece on your models. So, for example, if I turn this piece over and look at it, what should I do with it? E.g., you can use it or you can use it or if no one is using it, you turn it back over like it was (Get child to respond with options, prompt if necessary).*

[If child leaves over during task, remind them “Remember to do something with that piece.”]

*This timer (show timer) will show you how much time you have left. As soon as 3 minutes are up, you are done! Then, we will count the number of points your team won and we will record your team’s score on the scoreboard.*

*Okay, so as soon as I say GO! try to place as many coloured blocks as you can in 3 minutes. Remember team \_\_\_\_\_, you want to work together to earn the most points and you can earn the most points by completing as many colours of blocks as possible! Any questions?  
On your mark, get set, GO! (start timer)*

At the 2 minute 30 second mark, give warning “**You have 30 seconds left!**”

At the 2 minute 50 second mark, give warning “**You have 10 seconds left!**”

At exactly 3 minutes, say loudly and clearly “**Done!**”

When finished (stop timer and write time on score board):

*Okay, good job team! Let’s count your team’s points (count points with kids and write on scoreboard).*

*Great, your team won [number of] points!!*

*Now, we are going to do some other things in separate rooms.*

Appendix C

**Understanding of Wooden Block Social Task Questions**

1) What was the goal of this game?

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2) How many bonus points would someone get if they finished a whole colour?

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3) Were you and the other child working together or by yourselves?

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Appendix D

**Coding Criteria**

Note: For behaviours followed by an arrow, the child must complete one following behaviour in order to get a point

Note: Record both the letter of the behaviour and the time it occurred (as well as, the time frame to complete cooperative behaviours)

<b>Cooperative Behaviours</b>					
Initial Behaviour	2 points	1 point	1 point	1 point	1 point
Child Picks up a block	<p><b>a.</b> puts block in the right spot on OC's model</p> <p><b>b.</b> hands OC a block he/she needs or asked for</p>	<p><b>a.</b> places block face-down/face-up closer to OC than before</p> <p><b>b.</b> tosses/puts block on OC's model (without trying to find the right spot)</p> <p><b>c.</b> looks in OC's direction to see when OC is ready →</p> <p><b>d.</b> looks at OC's model (e.g., to see if need a block) →</p>	<p><b>a.</b> tosses/puts piece on OC's model (without trying to find the right spot)</p> <p><b>b.</b> places block face-down/face-up closer to OC's half</p>	<p><b>a.</b> looks in OC's direction to see if OC knows what to do with block →</p>	<p>If sees that OC doesn't know where to put a block:</p> <p><b>a.</b> Child tells OC where to put it</p> <p><b>b.</b> Child shows OC where to put it</p>
<b>Tally + Time (start to end)</b> (tally by putting letter of behaviour observed)					

Cooperative Behaviours		
Initial Behaviour	2 points	1 point
Child Looks Over at/Attends to Other Child/ OC's Model	<u>a.</u> tries to find a block for OC <u>b.</u> tries to/fixes a block(s) on OC's model <u>c.</u> tries to find where OC's block goes on OC's half	<u>a.</u> points to where a block should go <u>b.</u> points to model to show OC where block should go
<b>Tally + Time (start to end)</b> (tally by putting letter of behaviour observed)		

Cooperative Behaviours			
Initial Behaviour	2 points	1 point	1 point
Other Child Asks for (Child's) Help or Needs Help	<u>a.</u> helps to put a block in right spot physically/tries to find where OC's block goes on OC's half <u>b.</u> helps OC find a block that OC needs/has asked for <u>c.</u> passes a block to OC	<u>a.</u> stops work on own model to focus on OC/OC's model → <u>b.</u> looks at OC's model or OC → <u>c.</u> allows OC to take blocks from own model to add to OC's model	<u>a.</u> points to model to show OC where block goes <u>b.</u> helps OC reach a block <u>c.</u> moves block(s) closer to OC <u>d.</u> gives advice (count under Verbalizations)
<b>Tally + Time (start to end)</b> (tally by putting letter of behaviour observed)			

Cooperative Behaviours			
Initial Behaviour	2 points	1 point	1 point
Both children plan to work on one model first together, then the next model	<u>a.</u> child puts block in right spot on model agreed to work on <u>b.</u> helps OC find a block that need for the model agreed to work on <u>c.</u> gives a block that OC needs/wants to OC	<u>a.</u> helps OC find the right spot on agreed upon model <u>b.</u> waits for OC's arm to move out of the way before trying to place block on agreed upon model <u>c.</u> moves block(s) closer to OC	<u>a.</u> once a colour on first model is finished, places that coloured block on other model
<b>Tally + Time (start to end)</b> (tally by putting letter of behaviour observed)			

Cooperative Behaviours			
Initial Behaviour	2 points	1 point	1 point
OC offers help or advice	<u>a.</u> child thanks OC for help	<u>a.</u> child follows advice from OC (e.g., picking up a block OC suggests)	
<b>Tally + Time (start to end)</b> (tally by put letter of beh)			

<b>Cooperative Verbalizations</b>		
Instructions, advice, offers of help (2 points)	Planning (2 points)	Encouragement/Reassurance to Team/OC (1 point)
e.g., “Here, you take this block.” “This is yours.” “Do you need help?” “I’ll help you” “This block can go on your model here.”	e.g., “How about you work on the green colour and I’ll work on the blue.” “If I find a green colour, I’ll give it to you. If you find a blue colour, give it to me.” “Let’s work on one model together, then the other one.”	e.g., “We’re doing really good!” “Our team is going to win!” “Don’t worry.” “Good!” “Yayy!”

<b>Cooperative Verbalizations</b>		
Responding to OC’s comments/questions (1 point)	Checking on OC’s progress in a non-competitive way (1 point)	“We” statements about team (1 point)
e.g., “Oh yeah” “Okay” “True”	e.g., “How are you doing?” “You get any bonus points yet?”	e.g., “What if we don’t complete at least one. We don’t get points?” “We’re out of time!”

**Competitive Behaviours**

Initial Behaviour	2 points	1 point
Child Picks up a block that it has been agreed upon that the Other Child's needs/is looking for	<u>a.</u> puts piece back face-down further away from OC <u>b.</u> takes the piece and puts on own model <u>c.</u> hides piece from OC	<u>a.</u> puts piece back face-down where it was <u>b.</u> puts piece face-up, but further away from OC
<b>Tally and Time</b> (tally by putting letter of behaviour observed)		

**Competitive Behaviours**

Initial Behaviour	2 points	1 point
Child Picks up a block		<u>a.</u> puts piece back face-down/face-up further away from OC
<b>Tally and Time</b> (tally by putting letter of behaviour observed)		

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**Competitive Behaviours**

<b>Competitive Behaviours</b>		
Initial Behaviour	2 points	1 point
Child Looks Over at Other Child/OC's model	<b>a.</b> tries to block OC's access to blocks <b>b.</b> tries to take OC's blocks off of OC's half	<b>a.</b> behavioural bragging about own half in comparison to OC's: e.g., victory dance
<b>Tally and Time</b> (tally by putting letter of behaviour observed)		

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**Competitive Behaviours**

<b>Competitive Behaviours</b>		
Initial Behaviour	2 points	1 point
Other Child Asks for Child's Help	<b>a.</b> Shakes head 'no'	<b>a.</b> continues with work on own puzzle, ignoring OC
<b>Tally and Time</b> (tally by putting letter of behaviour observed)		

**Competitive Behaviours**

Initial Behaviour	2 points	1 point
Other child tries to help	<p><b>a.</b> grabs block back from OC's hand with OC's resistance (i.e., OC doesn't let go)</p> <p><b>c.</b> reacts aggressively – i.e., tries to hit the other child or spit at the other child</p> <p><b>d.</b> tries to push OC away</p> <p><b>e.</b> tries to stop OC from moving blocks to where they will earn more points</p>	<p><b>a.</b> ignores OC's behavioural or verbal attempts to help</p> <p><b>c.</b> ignores verbal advice from OC about where a block should go or what they should be doing e.g., continues working without changing behaviour/shifting focus</p> <p><b>d.</b> takes a block from OC's hand without OC's resistance (i.e., OC lets go)</p>
<b>Tally and Time</b> (tally by putting letter of behaviour observed)		

<b>Competitive Verbalizations</b>		
Remarks that violate agreed upon cooperation or refusal of helpful advice from OC (1 point)	Negative comments towards or about OC/OC's progress (1 point)	Comments about own progress compared to OC's (1 point)
e.g., "I want this block/colour." "I'm taking this block/colour." "I'm going to get all the colours." "No, I'm not going to do it that way."	e.g., "Wow, you're slow." "You are not that good at this." "Stop copying me." "Stop talking."	e.g., "I'm doing better than you!" "I'm going to win!" "I have more colours/blocks than you." "I've done more."
<b>Competitive/Aggressive Verbalizations</b>		
Denying help when OC asks help (2 points)	Refusal of OC's offering of help (2 points)	Very negative comments about OC (2 points)
e.g., "Stop bothering me!" "Leave me alone!"	e.g., "I don't want/need your help!" "I can do it myself!"	e.g., "You suck" "You're way worse than me!"

Neutral/Individual Behaviours		
Initial Behaviour	1 point	
Child Picks up a block	<b>a.</b> puts piece back face-down/face-up where it was <b>b.</b> puts block on own model (i.e., a colour block that there is no agreement between partners about)	
<b>Tally and Time</b> (tally by putting letter of behaviour observed)		

Neutral/Individual Verbalizations		
Comments about own individual progress (1 point)	Neutral comments related to the task (1 point)	Neutral/Social comments (1 point)
e.g., “I’m doing really good!” “Look at all the _____ I’ve got.” “Look, I’ve almost finished my red.” “Look at all the blocks I’ve picked up.”	e.g., “This one is pretty hard!” “One more for completing this colour” “Dude, don’t rush me!” Counting down “10, 9, 8...”	e.g., “I like your sweater”

## Appendix E

### **Bootstrap Analysis**

Because some of the variables in my analyses were significantly skewed, any significant results using SEM were re-analyzed using the bootstrap analysis. This type of analysis was used because it deals with skewed data better than the APIM. By using the bootstrap analysis, I can be reasonably confident in the results and that they were not just a result of having skewed data. This type of analysis involves a procedure that randomly draws a large number of resamples (with replacement) from the original sample data to create a large number of bootstrap samples, of which I used 5000 (Razza & Blair, 2009; Stine, 1989).

### **Relations between Cognitive Skills and Social Competence at Different Ages**

#### **Dyadic models: relations between cognitive skills and social behaviours.**

*Competitive behaviour.* To begin, the effect of cognitive skills on the proportion of competitive behaviours was investigated. All parameter estimates presented below are in standardized form.

First, to investigate the role of planning in the younger group, the model including planning (Tower task), theory of mind, vocabulary, age and competitive behaviour was examined. Results for the actor effect of planning on the proportion of competitive behaviours was marginally significant, while controlling for age and the actor and partner effects of the other predictor variables, ( $\beta = .19, p = .08$ ), indicating that younger children with better planning skills were displaying a marginally greater proportion of competitive behaviours. On the other hand, the actor effect of theory of mind on the proportion of competitive behaviours was marginally significantly negatively related, while controlling for age and the actor and partner effects of the other predictor variables, ( $\beta = -.37, p = .08$ ). Finally, the partner effect of theory of mind on the

proportion of competitive behaviours was significantly negatively related, while controlling for age and the actor and partner effects of the other variables ( $\beta = -.23, p < .05$ ). These results indicate that, for the younger group, those with better theory of mind displayed a marginally smaller proportion of competitive behaviours; furthermore, their theory of mind was having an effect on their partners' behaviours such that partners also displayed a smaller proportion of competitive behaviours.

For the older group, the actor effect of planning (i.e., Tower task) on the proportion of competitive behaviours was significant, while controlling for age and the actor and partner effects of the other predictor variables, ( $\beta = -.25, p < .05$ ), indicating that older children with better planning skills were displaying a smaller proportion of competitive behaviours. Furthermore, the actor effect of verbal skills (i.e., Vocabulary task) on the proportion of competitive behaviours was significant, while controlling for age and the actor and partner effects of the other predictor variables, ( $\beta = -.36, p < .05$ ). Finally, the partner effect of verbal skills on the proportion of competitive behaviours was marginally significant, while controlling for age and the actor and partner effects of the other variables ( $\beta = -.22, p = .08$ ). These results indicate that, for the older group, those with better verbal skills displayed a smaller proportion of competitive behaviours; furthermore, their verbal abilities were having a marginally significant effect on their partners' behaviours such that partners also displayed a smaller proportion of competitive behaviours.

Similar models were run to investigate the effect of inhibitory control (i.e., Go/No-go task) and working memory (i.e., Finger Windows task) on the proportion of competitive behaviour. There were no significant actor or partner effects of inhibitory control or working memory on the proportion of competitive behaviours for either age group. Thus, when

controlling for age, theory of mind and verbal skills, older and younger children's inhibitory control and working memory do not appear to influence competitive behaviour displayed during a cooperative social task. It is noteworthy that the actor and partner effect of theory of mind remained significant for the younger group and the actor effect of verbal skills remained significant for the older group, controlling for inhibitory control and working memory.

To summarize, these results indicate that different cognitive skills were having unique effects on competitive behaviours in each age group. While better planning skills were related to marginally more competitive behaviours in younger children, better planning skills were related to fewer competitive behaviours in older children. Furthermore, while better theory of mind skills were related to marginally fewer competitive behaviours in younger children and significantly fewer in their partners, better verbal skills were related to fewer competitive behaviours in older children and marginally fewer in their partners.

*Cooperative behaviour.* Next, the effect of cognitive skills on the proportion of cooperative behaviours was investigated.

First, to investigate the role of planning in the younger group, the model including planning (Tower task), theory of mind, vocabulary, age and cooperative behaviour was examined. There were no significant effects of planning on the cooperative behaviour. There were also no significant effects of theory of mind or verbal skills on cooperative behaviour.

For the older group, there were no significant effects of planning on the cooperative behaviour; however, the actor effect of theory of mind skills on the proportion of cooperative behaviours was significant, ( $\beta = .18, p < .01$ ). Furthermore, the partner effect of theory of mind skills on the proportion of cooperative behaviours was significant, ( $\beta = .17, p < .05$ ). This indicates that, for the older group, those with better theory of mind skills displayed a

significantly greater proportion of cooperative behaviours; furthermore, their theory of mind skills were having a significant effect on their partners' behaviours such that partners also displayed a greater proportion of cooperative behaviours.

For the older group, there were no significant effects of inhibitory control or working memory on cooperative behaviour. It is noteworthy that the actor and partner effect of theory of mind remained significant in both of these models, controlling for inhibitory control and working memory.

To summarize, the cooperative behaviours in only the older group seemed to be influenced by cognitive factors. Specifically, better theory of mind skills were related to more cooperative behaviours in older children and their partners, even when controlling for executive functions.

### **Moderating Effects of Executive Functioning**

The third aim of this study was to explore whether EF components moderate the relationship between symptoms of ADHD or ODD/CD and social skills, as well as whether these relationships change with age. All parameter estimates presented below are in unstandardized form.

#### **Moderating effects of executive functioning on parent ratings of social skills.**

For the older group, the model including working memory, ADHD, the interaction term, and the dependent variable Total Social skill revealed a main effect of ADHD symptoms ( $B = -.14, p < .01$ ), indicating that as children have fewer ADHD symptoms they are more socially skilled. There was also a significant interaction term, that is, the interaction of working memory and ADHD symptoms was having a significant effect on Total Social skill ( $B = .01, p = .02$ ). This interaction effect indicates that ADHD symptoms in older children have less of a negative

effect on social skills when working memory is strong than when it is relatively weak. When adding ODD/CD symptoms and its interaction term into this model in order to control for this other symptoms profile and its interaction with working memory, the main effect of ADHD was significant ( $B = -.09, p < .04$ ); however, the interaction effect of ADHD and working memory was no longer significant ( $B = .01, p > .05$ ).

To summarize, for older children, working memory and ADHD interacted to have a significant effect on parent rated social skills; however, this interaction effect was not unique to ADHD, when controlling for the other symptom profile of ODD/CD and its interaction with working memory.

**Dyadic models: moderating effects of executive functioning on social behaviours.**

**Competitive behaviour.** When looking at symptoms of ADHD in the older age group, the model including working memory, ADHD, the interaction term and the dependent variable competitive behaviours revealed a significant partner main effect of ADHD symptoms ( $B = .03, p < .01$ ), indicating that as children have more ADHD symptoms their partners display more competitive behaviours. There was also a marginally significant interaction term, that is, the interaction of working memory and ADHD symptoms had a marginally significant actor effect on competitive behaviours ( $B = -.02, p = .06$ ). This interaction effect showed that if older children had worse working memory, more ADHD symptoms were related to more competitive behaviours; whereas, if they had relatively better working memory, this relationship was no longer positive. When adding ODD/CD and its interaction term to this model, in order to control for this other symptom profile and its interaction with working memory, the partner main effect of ADHD was no longer significant. On the other hand, the partner main effect of ODD/CD was significant ( $B = .07, p = .02$ ) and the interaction effect of ADHD and working memory was

marginally significant ( $B = -.02, p = .07$ ). This suggests that the interaction between ADHD and working memory had a marginally unique effect on competitive behaviour, even when controlling for ODD/CD and its interaction with working memory.

The model including planning, ADHD, the interaction term and the dependent variable competitive behaviours revealed a significant partner main effect of ADHD symptoms ( $B = .04, p < .01$ ); however, there was no significant interaction effect of planning skills and ADHD symptoms on competitive behaviours. When adding ODD/CD and its interaction term to this model, in order to control for this other symptom profile and its interaction with planning, the partner main effect of ADHD was no longer significant ( $B = .00, p > .05$ ). On the other hand, the partner main effect of ODD/CD was significant ( $B = .08, p = .01$ ).

The model including planning, ODD/CD, the interaction term and the dependent variable competitive behaviours revealed a significant partner main effect of ODD/CD symptoms ( $B = .12, p < .01$ ) and a significant interaction term. That is, the interaction of planning skills and ODD/CD symptoms had a significant actor effect on competitive behaviours ( $B = -.04, p = .02$ ). This interaction effect showed that if older children had worse planning skills, more ODD/CD symptoms were related to more competitive behaviours; whereas, if they had relatively better planning skills, this relationship was no longer positive. When adding ADHD and its interaction term to this model, in order to control for this other symptom profile and its interaction with planning, the partner main effect of ODD/CD symptoms remained significant ( $B = .08, p < .01$ ); the interaction effect of ODD/CD and planning was no longer significant ( $B = .01, p > .10$ ). This suggests that the interaction between ODD/CD and planning did not have a unique effect on competitive behaviour, when controlling for ADHD and its interaction with planning.

Finally, the model including inhibitory control, ODD/CD, the interaction term and the dependent variable competitive behaviours revealed a significant partner main effect of ODD/CD symptoms ( $B = .08, p < .01$ ) and a marginally significant interaction term. That is, the interaction of inhibitory control and ODD/CD symptoms had a marginally significant actor effect on competitive behaviours ( $B = -.32, p = .05$ ). When adding ADHD and its interaction term to this model, in order to control for this other symptom profile and its interaction with inhibitory control, the partner main effect of ODD/CD was marginally significant ( $B = .07, p = .07$ ) and the actor and partner interaction effect of ODD/CD and inhibitory control were only marginally significant ( $B = -.77, p = .07; B = .51, p = .07$ ). There was a significant actor main effect of ADHD symptoms ( $B = .05, p < .01$ ), such that more ADHD symptoms was related to more competitive behaviours.

To summarize, these results indicate that only in the older group did executive functions interact with different symptom profiles to somewhat uniquely affect competitive behaviours. Specifically, working memory interacted with ADHD symptoms to uniquely affect older children's competitive behaviour, even when controlling for the other symptom profile of ODD/CD and its interaction with working memory and planning skills. Interestingly, only symptoms of ODD/CD had a unique main effect on partners' competitive behaviours when controlling for ADHD symptoms, such that, as ODD/CD symptoms increased so did partners' competitive behaviours.

***Cooperative behaviour.*** For the older group, the model including inhibitory control, ADHD, the interaction term and the dependent variable cooperative behaviours revealed a significant interaction term. That is, the interaction of inhibitory control and ADHD symptoms was having a significant actor and partner effect on cooperative behaviours ( $B = 4.61, p = .01$

and  $B = 5.33$   $p = .01$ , respectively). This interaction effect indicated that if older children had better inhibitory control, fewer ADHD symptoms were related to more cooperative behaviours; whereas, if they had relatively worse inhibitory control, this relationship reversed. As well, the interaction of children's inhibitory control and ADHD had a significant effect on their partners' cooperative behaviours. This interaction effect indicated that if older children had better inhibitory control, fewer ADHD symptoms were related to more cooperative behaviours from partners; whereas, if they had relatively worse inhibitory control, this relationship was no longer positive. When adding ODD/CD and its interaction term to this model, in order to control for this other symptom profile and its interaction with inhibitory control, the actor and partner interaction effects of ADHD and inhibitory control remained significant or marginally significant ( $B = 8.95$ ,  $p < .01$  and  $B = 8.95$ ,  $p < .05$ , respectively). This suggested that the interaction between ADHD and inhibitory control had a unique effect on one's own cooperative behaviour and one's partners' cooperative behaviour, even when controlling for ODD/CD and its interaction with inhibitory control.

To summarize, results demonstrate that only in the older group did executive functions interact with different symptoms profiles to affect cooperative behaviours. Specifically, inhibitory control skills interacted with ADHD symptoms to uniquely affect one's own cooperative behaviour and one's partner's cooperative behaviour, even when controlling for the other symptom profile of ODD/CD and its interaction with inhibitory control. On the other hand, no executive functions interacted with ODD/CD symptoms to uniquely affect cooperative behaviour.

## Appendix F

### Results Summary

Key results are summarized in this section. Please note that any results analyzed by both SEM and bootstrap analysis are summarized below only if a similar pattern of findings was found in both analyses.

#### **Research Question 1: What are the unique contributions of executive functions, theory of mind, and verbal skills on social competence at different ages?**

Approach: The relationship between cognitive skills and children's social skills (parent-report and interactive social task), while controlling for the other cognitive skills (executive function components, theory of mind, and/or verbal skills) was examined:

##### Parent-reported social skills:

- For the younger group, better theory of mind skills were related to better overall social skill.
- The effect of theory of mind on social skills in the younger group was not significantly different from the older group

##### Social task: Competitive behaviours:

- For the younger group, better planning skills were related to more competitive behaviours
- For the older group, better planning skills were related to fewer competitive behaviours
- For the younger group, better theory of mind skills were related to fewer competitive behaviours in children and their partners
- For the older group, better verbal skills were related to fewer competitive behaviours in children and their partners

- The effect of planning on competitive behaviour was significantly different between the younger and older groups
- Correlation between theory of mind and competitive behaviour (actor and partner) was significantly stronger in the younger group compared to the older group.

Social Task: Cooperative behaviours:

- For the older group, better theory of mind skills were related to more cooperative behaviours
- The effect of theory of mind was not significantly different between the younger and older groups

**Research Question 2: Are executive functioning skills related to symptoms of ADHD or ODD/CD while controlling for the other symptom profile?**

- Executive functioning components did not uniquely relate to symptoms of ADHD in either age group
- Only inhibitory control was marginally significantly related to symptoms of ODD/CD in the older group, when controlling for symptoms of ADHD

**Research Question 3: Do executive functioning components moderate the relationship between symptoms of ADHD or ODD/CD and social skills and how do these relationships change with age?**

Approach: The interaction effect of executive functions and symptoms of ADHD and ODD/CD on social skills (parent-report and interactive social task) were examined.

Parent-reported social skills:

- For the younger group, executive functioning did not interact with ADHD or ODD/CD symptoms to affect parent-rated social skills

- For the older group, ADHD had a main effect on parent-rated social skill
- For the older group, working memory and ADHD interacted to have an effect on social skill
- For the older group, the main effect of ADHD on social skills was unique to this disorder, but the interaction effect was not unique to ADHD, when controlling for the other symptom profile of ODD/CD and its interaction with working memory
- While the interaction effect of working memory and ADHD on social skill was significantly different in the older group compared to the younger group, this difference did not remain when controlling for ODD/CD and its interaction with working memory

Social Task: Competitive Behaviours:

- For the younger group, executive functioning did not interact with ADHD or ODD/CD symptoms to affect social behaviour
- For the older group, working memory interacted with ADHD symptoms to uniquely affect older children's competitive behaviour, even when controlling for the other symptom profile of ODD/CD and its interaction with working memory
- For the older group, ODD/CD symptoms had a unique effect on partner's competitive behaviours, while controlling for ADHD symptoms

Social Task: Cooperative behaviours:

- For the younger group, executive functioning did not interact with ADHD or ODD/CD symptoms to affect social behaviour
- For the older group, inhibitory control skills interacted with ADHD symptoms to uniquely affect one's own and one's partner's cooperative behaviour, even when

controlling for the other symptom profile of ODD/CD and its interaction with inhibitory control

- The interaction effect in the older group was significantly different from the younger group, even when controlling for the other symptom profile of ODD/CD and its interaction with inhibitory control