Reasons for the Sex Difference in the Prevalence and Age of Autism Spectrum Disorder Diagnosis

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B.Psych (Hons)

A thesis submitted in partial fulfilment of the requirements for the degree of

Doctor of Philosophy (Clinical Psychology)

Flinders University

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Faculty of Social and Behavioural Sciences

December 2013

Abstract

In the absence of intellectual impairment, girls are diagnosed with Autism Spectrum Disorder (ASD) both substantially less and later than boys. In this thesis I explored potential reasons for the sex difference in the prevalence and age of the diagnosis of ASD. Two theories were explored. First, girls may genuinely develop ASD less than boys, due to an advantage in the typical development of cognitive and environmental factors associated with social development. Alternatively, girls may be better able to hide their underlying impairments and present with different overt behaviours, resulting in the under-detection of the disorder. While little evidence was found for the first theory, across two studies I found evidence to support the theory that ASD presents differently girls, and is thus potentially more difficult to detect. Findings indicate that the current estimate of the rate of ASD in girls likely underestimates the true prevalence of the disorder in this population.

To investigate whether girls may genuinely develop ASD at a lesser rate to boys, I explored sex differences in the cognitive and social profiles of typically-developing pre-schoolers. In particular, I focussed on cognitive factors (theory of mind and executive function), communication style with parents (mental state talk), and play style, all of which are linked to social development. Results from 68 pre-school aged children (27 girls) failed to show robust evidence of girls being protected by better developed cognitive or social skills. While girls were more readily exposed to complex social environments, through parent-interaction and through a preference for pretend-play, this was not related to more advanced social competence.

However, robust evidence was found for the second theory, that girls may be diagnosed less with ASD due to the under-detection of the disorder. This theory was investigated over two studies. In the first, I explored the pre-diagnosis concerns of 152

caregivers (60 of girls) whose cognitively able children were late-diagnosed with ASD. In the second, I explored sex differences in a sample of 69 boys and 69 girls all diagnosed with ASD, based on clinician and teacher ratings. Evidence across both studies showed girls were reportedly better able to imitate, and use this in a social environment in an attempt to copy social interactions. Further, while girls were equally impaired as boys in some key underlying social impairments, this manifested in quite different overt behaviours. It is likely many of these overt behaviours (e.g., better use of nonverbal gestures) further camouflages girls' underlying impairments. This ability to camouflage seemed most notable when in school, with teachers reporting far fewer concerns for girls than for boys, including the majority of girls being rated by teachers as having quite typical social skills. Outside of the social domain, girls were also found to present with different types of restricted interests to boys, which were potentially more difficult to detect as atypical, or indeed as a sign of ASD. Results provided insight into why the disorder may be more difficult to detect in girls, particularly in the younger years and by professionals not specifically trained in the diagnosis of ASD. Further, results provide a framework for how we can better identify the disorder in girls.

Declaration

I certify that this thesis does not incorporate, without acknowledgement, any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person, except where due reference is made in the text.

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Acknowledgements

First, thank you to Robyn Young and Nathan Weber, for the time and effort you have put into this project and my development as a researcher. This project was made possible through your knowledge and expertise and I cannot thank you enough for all that you have taught me over the past four years.

Nicole, Caitlin, Sammy, Mel, Anne, Mike, Tomoko and Lydia, you made the past four years the complete opposite of the "isolating PhD experience", full of laughter, slightly exaggerated stories, the occasional long lunch and Schnitmas. Thank you also to Claire, Amelia and Alyssa, for contributing to this research in one way or another, whether that was cooking dinner, pouring me a glass of wine, or proof reading drafts (all were equally appreciated!). A special mention must also go to the teams from Flinders ASD Research and the Flinders University Child & Adolescent Sleep Clinic. In particular, thank you to Michael Gradisar, for the extremely generous support, encouragement and time you have provided me over the past few years.

Thank you to my family - mum, dad, Megan, Sarah and Georgie. You have always supported me and only occasionally questioned my apparent desire to never stop being a university student. Thank you also to Simon. You had to live with me for much of my PhD, so possibly deserve the most credit. I am ever grateful for your support. A special mention must also go to Louie, just to make those who know me roll their eyes.

Finally, I would like to sincerely thank all of the schools, parents and children who participated in this research. Your willingness to give your precious time and energy to research is what allows us to continue to learn more and more about autism spectrum disorder.

Chapter 1: Introduction

Overview

Autism Spectrum Disorder is a pervasive developmental disorder, characterised by developmental delays in social-communication abilities and restricted/repetitive behaviours (American Psychiatric Association, 2013). The disorder is usually diagnosed in childhood and may or may not present with comorbid intellectual disability and severe language impairment. When severe language impairment and intellectual impairment are absent, the label Asperger's Disorder has traditionally been used (American Psychiatric Association, 2000). In 2013, the fifth edition of the diagnostic statistical manual was released (DSM-5; American Psychiatric Association, 2013). The DSM-5 combines previous diagnostic labels of Autistic Disorder, Asperger's Disorder, Childhood Disintegrative Disorder and Pervasive Developmental Disorder, not otherwise specified (PDD-NOS) under the umbrella term of Autism Spectrum Disorder. On the release of the DSM-5, the diagnostic criteria changed from a triad of impairments to a dual diagnostic system. This includes social-communication impairments (e.g., deficits in social-emotional reciprocity, difficulty initiating friendships, deficits in non-verbal behaviour) as well as the presence of restricted and repetitive interests (including fixated interests, routine adherence, and sensory sensitivity). In line with recommendations made by the DSM-5, I will use the term Autism Spectrum Disorder (ASD) to encompass Autistic Disorder, Asperger's Disorder, and PDD-NOS, with high-functioning ASD or cognitively-able referring to the disorder when present without comorbid intellectual impairment or severe language delay.[1]

[1] While the term ASD also encompasses Childhood Disintegrative Disorder, this sample was not targeted in this thesis.

One of the most consistent yet under-researched areas in the literature on ASD is the large sex difference in the diagnostic rates. Prevalence studies estimate boys are diagnosed at a rate four times more than girls. Moreover, when ASD is not comorbid with intellectual impairment or severe language delay, this diagnostic ratio increases to around ten boys diagnosed to every one girl (Fombonne, 2009; Rivet & Matson, 2011). In the absence of intellectual impairment, there is also evidence that girls with ASD are diagnosed up to 1.5 years later than their male counterparts (Begeer et al., 2012; Siklos & Kerns, 2007). Consequently, it is rare for a cognitively-able girl to be diagnosed before school age, meaning many miss early intervention, or potentially crucial support for the child and their family (Dworzynski, Ronald, Bolton, & Happé, 2012; Warren et al., 2011).

It is currently unclear why these sex differences exist. Potential explanations include that girls are somehow biologically protected from developing ASD as readily as boys (Baron-Cohen, 2002; Szatmari et al., 2012; Werling & Geschwind, 2013), that the disorder is inherently different in boys and girls, or that ASD, as it is currently know, occurs more equally in girls, but that the deficits are somehow less apparent in this population (Dworzynski, et al., 2012; Kothari, Skuse, Wakefield, & Micali, 2013). Indeed, the sex discrepancy at the cognitively-able end of the spectrum may be a combination of these explanations. In this thesis I explored two potential reasons for the sex discrepancy in the prevalence and age of ASD diagnoses. First, the disorder may genuinely occur less in females because the abilities that allow children to develop typical social skills may develop better in girls. Alternatively, the disorder may occur more equally across the sexes, but may be detected less in females, because the underlying impairments at the core of ASD manifest in a different behaviour presentation in girls, resulting in the under-detection of the disorder.

In this thesis, I have explored three distinct samples to provide a comprehensive exploration of why ASD is diagnosed less and later in girls. First, I investigated sex differences in typically developing children to explore whether a true prevalence difference may result from girls having protective factors that reduce the likelihood that they will develop ASD. Second, over two studies, I explored whether the prevalence difference may not be genuine, at least of the current magnitude, and rather an artefact of the difficulty identifying the disorder in girls. This included an examination of sex differences in pre-diagnosis concerns; to explore what concerns led parents to seek professional opinion on their child's development and the responses of health care professionals to these concerns. Further, I examined sex differences in the behavioural presentation of children and adolescents with a current ASD diagnosis. This involved a larger sample of girls and moved beyond the broad diagnostic criteria to explore whether underlying impairments may manifest in different overt behaviour presentations for boys and girls.

Theory 1: Are Girls Less Likely to Meet ASD Criteria Due to a Typical Advantage in Social Development?

One explanation for the sex difference in the prevalence rates of ASD, is that girls are genuinely less likely to meet criteria due to an advantage in the development of abilities associated with social functioning, a key impairment in ASD (American Psychiatric Association, 2013). To explore this, I was interested in whether an early female advantage in typical cognitive, language, and resulting social development, may protect girls from meeting some or all criteria for ASD. The rationale for this line of research originates from the *extreme male brain theory* (Baron-Cohen, 2002; Baron-Cohen & Hammer, 1997; Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997). The extreme male brain theory has proposed that girls are biologically protected from

meeting criteria for ASD due to a gender advantage in processes commonly impaired in the disorder (e.g., empathy; Baron-Cohen, 2002; Baron-Cohen & Hammer, 1997). This theory was an extension of the systemising-empathising theory and suggests females are biologically advantaged in their empathising (the desire to identify and respond to another's emotions), while the male brain shows a propensity for systemising (focussing on detail, and the deterministic rules that govern behaviour). Baron-Cohen and Hammer (1997) suggested this systemising brain, in the extreme, is demonstrated in people with ASD (e.g., the fixation to detail, preference for rules, and collecting behaviour).

Some support has been found for this hypothesis, with higher levels of autistic traits found in general-populations of boys compared to girls (Constantino & Todd, 2003). Moreover, recent evidence suggests girls may require a higher genetic liability to express restricted interests, a key criterion for ASD (Szatmari, et al., 2012). Likewise, in support for the extreme male brain theory, there is also evidence of a female advantage in empathy from the pre-school years to adulthood (Baron-Cohen & Wheelwright, 2004; Roberts & Strayer, 1996; Tilburg, Unterberg, & Vingerhoets, 2002). However, in a review on sex differences in children's social and emotional development, it was noted that findings on sex differences in regards to empathy, were largely dependent on how the variable was operationalised (Rose & Rudolph, 2006), with evidence of no sex difference in children's empathy, based on teacher- and peer-report (Roberts & Strayer, 1996). Consequently, it is not yet understood whether girls have genuinely better developed empathy, or are simply better at reporting how one should act in a social situation. It is also not yet clear whether sex differences reflect biological differences or differences in the early social environments of boys and girls (Constantino & Todd, 2003). Further, while empathy has received much attention in the literature, and support

for the extreme male brain theory remains inconsistent, there are numerous other potentially important mechanisms, related to social development, which may play a role in protecting girls from developing social deficits as readily as boys.

One cognitive ability of importance to social development, and often implicated in the development of ASD, is theory of mind. Theory of mind refers to a person's ability to interpret the perspective of others, how it may differ from the self, and how this perspective may shape their behaviour (C. Hughes & Leekam, 2004) (Premack & Woodruff, 1978). This includes understanding that others may want, know, or think differently from oneself, meaning the ability to impute the mental states of both others and oneself. Underpinning this cognitive process are such mechanisms as metarepresentation and pretence (Charman & Baron-Cohen, 1992; Leslie, 1987). Metarepresentation, as an example, is defined as the child's ability to represent another's beliefs, thoughts or knowledge towards something (Charman & Baron-Cohen, 1992; Leslie & Happe, 1989). Theory of mind is of interest to the field of autism research given its link to social functioning (C. Hughes & Leekam; Lillard, 1993; Watson, Nixon, Wilson, & Capage, 1999). Typically developing children with greater theory of mind understanding have shown superior social functioning both in longitudinal (Watson, et al., 1999) and cross-sectional (Bosacki & Wilde Astington, 1999) research. Further, while children with autism will most often fail theory of mind tasks (Frith, 1994; Happé, 1995), those who do pass have demonstrated more advanced social insight, compared to those who fail such tasks (Frith, 1994, Wellman et al. 2001).

Research already shows some evidence that females may develop more advanced theory of mind ability, with evidence of a female advantage in the pre-school years (Carlson & Moses, 2001; Charman, Ruffman, & Clements, 2002; Walker, 2005), school years (Bosacki & Wilde Astington, 1999; Calero, Alejo Salles, & Sigman, 2013),

and adulthood (Baron-Cohen, et al., 1997). However, the strength of the association between theory of mind and sex differs substantially. For example, Charman and colleagues (2002) showed evidence of only a weak female advantage in theory of mind in a sample of over 1000 two to six year old children, while Walker (2005) found evidence of a strong (Cohen's d = 1.23 – 3.05) female advantage in a sample of 112 three to five year olds. Further, evidence also points to no significant sex difference in theory of mind abilities (Devine & Hughes, 2013; C Hughes & Dunn, 1998; Mathieson & Banerjee, 2011), including a large-scale longitudinal study, which found no evidence of a significant sex difference in theory of mind ability at five-, six-, or seven-years of age (Caputi, Lecce, Pagnin, & Banerjee, 2012). One potential reason for these inconsistencies was that Caputi and colleagues (2012) controlled for receptive vocabulary, while the previously discussed studies either included no vocabulary measure (Walker, 2005) or had vocabulary information on a small number of participants (Charman, et al., 2002). Vocabulary is a strong predictor of theory of mind performance, and is particularly important to control for given the verbal nature of most theory of mind tasks (Cutting & Dunn, 1999; Happé, 1995). However, even when language is controlled for, evidence shows both a female advantage in theory of mind (Carlson & Moses, 2001) and no sex differences (e.g., Caputi, et al., 2012). Potentially, differences in findings may reflect a developmentally sensitive period for a female advantage in theory of mind. That is, as suggested by Caputi and colleagues, girls may be advantaged in their earlier development of theory of mind, shown during the pre-school years, but typically developing boys are largely able to 'catch-up' by school age. Alternatively, as suggested by Charman and colleagues (2002), mixed evidence of the presence or absence of sex differences in theory of mind may be the result of the difference only being a weak effect.

Our ability to draw conclusions on the role of a potential female advantage in theory of mind has thus far been limited by two major methodological limitations. The primary methodological limitation has been the sole focus on false belief ability as a single measure of theory of mind. Given false belief ability does not develop until approximately three and a half to four years of age, this focus on false belief particularly impedes our understanding of potential sex differences in the toddler and early pre-school years (i.e., under 3.5 years old; Wellmann, Cross, & Watson, 2001). Despite false-belief ability not developing until the later pre-school years, studies using younger samples (e.g., 2 year olds; Charman, et al., 2002; and 3 year olds; Walker, 2005) have used continued to use false belief as their primary measure of theory of mind. Moreover, the extensive focus on false-belief is in contrast to knowledge that theory of mind encompasses a range of processes that develop well before the age one would expect to see false belief emerge. Consequently, there is little evidence of theory of mind ability (and whether a sex difference exists) under four years of age (C. Hughes & Leekam, 2004). If a female advantage in theory of mind did exist in toddlerhood and the early pre-school years, it may have important implications for why ASD is less likely to occur in girls.

A second issue affecting our ability to draw conclusions on the role of theory of mind development is the concerning lack of well-validated and reliable measures for theory of mind as a construct. Even for the most commonly used theory of mind task (false belief), there is debate about its psychometric properties, with evidence of strong (A. Hughes, Happe, Jackson, Taylor, & Caspi, 2000), moderate (Charman & Campbell, 1997), and poor (L. Mayes, Klin, Tercyak, Cicchetti, & Cohen, 1996) reliability. Indeed, this issue in itself may explain the inconsistency in findings between studies, as it is not yet clear if the task commonly used to assess theory of mind accurately tap the

construct of interest. Unsurprisingly, the little information on theory of mind, pre false belief, means there is a particular lack of well-validated measures for testing theory of mind in the toddler and early pre-school years.

These two methodological issues are targeted in Chapters 2 and 3 of the thesis, where I have investigated the usability of a theory of mind scale (Peterson, Wellman, & Lui, 2005; Wellman & Liu, 2004) proposed to measure a range of theory of mind abilities that emerge prior to false belief ability. While this scale has been proposed to provide an accurate measure of early theory of mind ability, even prior to false belief, thus far the scale's use has focussed on age ranges of children where one would expect false belief ability to have emerged (i.e., 3.5 year olds to 12 year olds; Shahaeian, Peterson, Slaughter, & Wellman, 2011; Wellman, Fang, & Peterson, 2011). Consequently, I was particularly interested in the scale's usability with children from toddlerhood and thus its ability to detect sex differences in the pre false belief skills of typically developing children.

Could sex differences in executive function explain a female advantage in theory of mind? I was also interested in whether certain cognitive or language processes, linked to theory of mind, could provide insight into why girls may present with the hypothesised better developed theory of mind skills. The first construct of interest was executive function ability. Executive function is a cognitive construct comprised of three related abilities; (i) shifting, (ii) updating, and (iii) inhibition (Miyake et al., 2000). Shifting (also referred to as attention-shifting) is the ability to shift between different tasks, including the ability to disengage in irrelevant tasks and engage in relevant tasks. Updating is closely linked to working memory and is proposed to be the ability to manage, monitor and update information. Finally, inhibition is the ability to inhibit certain responses, including the inhibition of inappropriate behaviours

(Miyake, et al., 2000). A recent review of the executive function of pre-schoolers found all three of these executive function abilities appeared to develop early in the pre-school years (Garon, Bryson, & Smith, 2008). As such, like for theory of mind, the pre-school years represent a dynamic period of development for executive function. Further, executive function ability also has implications for social development, including associations with better ratings of social skills and lower ratings of disruptive behaviour and attention problems (Olson, Sameroff, Kerr, Lopez, & Wellman, 2005; Rhoades, Greenberg, & Domitrovich, 2009)**.**

Executive function was of most interest to this thesis due to its early association with theory of mind (Carlson & Moses, 2001; C. Hughes & Ensor, 2007; Pellicano, 2010). There are a number of potential theoretical explanations for the association between these two cognitive constructs, including that some executive function ability is required, although not solely, for the emergence of theory of mind (emergence theory), that theory of mind ability cannot be expressed until some executive function ability has development (expression account), that executive function development is dependent on earlier theory of mind development, or that the tasks used to assess each construct require the same reasoning skills (e.g., see Moses & Tahirogulu, 2009; Sabbagh, Moses & Shiverick, 2006).Indeed, much research has demonstrated an association between executive function and theory of mind, including Carlson and Moses (2001) who found significant positive associations between the inhibitory control ability and false belief theory of mind ability of 3-4 year old children. Moreover, evidence suggests this association also holds true for atypical samples, including children with ASD (Pellicano, 2010) and in cross cultural samples (Sabbagh, et al., 2006). Longitudinal studies have also explored whether executive function may precede theory of mind, or visa-versa. Based on the current literature, the explanation

garnering most support is that theory of mind emerges following the development of executive control (Hughes, 1998; Hughes & Ensor, 2007; Moses & Tahirogulu, 2009; Pellicano, 2010). That is, longitudinal research suggests executive function development may be necessary for the development of theory of mind, rather than visa-versa (Pellicano, 2010). Consequently, results from these longitudinal studies have suggested that executive function ability is a necessary, although likely not the sole component necessary, for theory of mind development (Moses & Tahirogular, 2010; Pellicano, 2010). Based on the association between these variables, I was interested in whether the proposed sex differences in early theory of mind may be due to sex differences in executive function performance. That is, could there be evidence of an overall female advantage in cognitive abilities related to social development?

There is some evidence of a female advantage in the executive function abilities of pre-school aged children (Carlson & Moses, 2001). This is particularly true for the ability to inhibit behavioural responses (i.e., inhibitory control; Carlson & Moses, 2001). In this thesis I was particularly interested in the further exploration of sex differences in various early executive function abilities and their association with a broader range of early theory of mind abilities. In particular, I was interested in furthering understanding on what specific theory of mind tasks, particularly pre false belief development, may be associated with executive function ability.

Could sex differences in environmental influences explain a female advantage in theory of mind? Research shows theory of mind development is also influenced by environmental factors, including number of siblings, type of parent interactions, and imagination (for review see, C. Hughes & Leekam, 2004). Indeed, research by Charman and colleagues (2002) on sex differences in pre-school theory of mind development hypothesised that the slight female advantage in theory of mind may

be due to girls being more readily exposed to environments that promote its development. This supports findings that, in the general population, higher autistic traits in young males than females, may be the result of females being more sensitive to early environments that promote social competency rather than biological differences (Constantino & Todd, 2002).

The use of mental state talk by parents, when interacting with their child, is one such environment that may promote social competence, through its association with theory of mind development (C Hughes & Dunn, 1998; Ruffman, Perner, & Parkin, 1999; Ruffman, Slade, & Crowe, 2002)**.** These mental state utterances may include making reference to emotions (e.g., "happy", "sad", "worried"), thought processes (e.g., "I thought", "Did you know"), or desires (e.g., "wish", "want", "like"). Longitudinally, early mental state talk, when engaged in interactions with parents, has been positively associated with children's later theory of mind development (Ruffman, et al., 2002). However, again, we know little about associations between mental state talk and theory of mind, outside of false belief ability.

Research shows that compared to boys, girls are more readily exposed to mental state talk during interactions. Specifically, parents of girls, compared to parents of boys, have been found to make significantly more references to mental state talk during interactions with their child (Cervantes & Callanan, 1998; Fivush, Brotman, Buckner, & Goodman, 2000). For example, Fivush and colleagues (2000), with a sample of 21 children aged 2 to 4 years old, found girls were exposed to significantly more utterances about emotions, than were boys. This was particularly the case when discussing emotional events during the parent-child interaction. Based on this evidence, girls may develop more advanced theory of mind during the pre-school years because they are more readily exposed to situations where they are able to practice perspective taking.

However, research has also shown that girls make more frequent references to mental states (Cervantes & Callanan, 1998; C Hughes & Dunn, 1998). For example, Hughes and Dunn (1998) examined the mental state use in 25 pairs of friends (i.e., 50 children) aged between 3 and 6 years old and found young girls used both more frequent and more advanced mental state utterances compared to boys. This difference was most pronounced at the final time point measured, when the children were around five years of age. As such, parents more frequent use of mental state talk with daughters, may actually reflect parents simply matching their daughters more advanced use of mental state talk, rather than parents 'causing' the more advanced language in girls. The longitudinal impact of parents' use of mental state talk was explored by Taumoepeau and Ruffman (2008) when children were 15, 24 and 33 months of age. They found early parental mental state talk did uniquely predict children's later mental state use and emotion understanding, suggesting parents' use of these utterances promotes children's social learning. In this thesis I will further explore the role of sex differences in parent and child use of mental state talk, and in particular how it may be associated with a female advantage in early theory of mind ability.

Summary for theory 1: Are girls protected from meeting criteria for ASD?

In sum, the first study in this thesis was designed to explore whether girls may develop better skills related to social development (a key impairment in ASD). The primary focus of this investigation was whether young girls would present with more advanced theory of mind abilities compared to boys. Factors that may explain why girls are advantaged in early theory of mind were also explored. This included executive function and mental state talk, both said to precede the development of theory of mind. Given theory of mind, or lack thereof, is linked to ASD, it is possible a female advantage in the ability may protect girls from developing ASD as readily as boys.

Theory 2: Could ASD Occur More Frequently in Girls but be Under-Detected?

A second potential reason for the sex difference in the diagnostic rates of ASD is that, despite the disorder being present, it is under diagnosed in girls. That is, ASD may occur more equally in the sexes (or at least not of a magnitude of 10:1) but be under detected in girls, due to differences in how the overt behaviours manifest. Research has shown that the time lapse between when a parent first expresses concern and when a child first receives a diagnosis of ASD is more pronounced for females, suggesting that the female presentation of the disorder is indeed more difficult to identify (Begeer, et al., 2012; Siklos & Kerns, 2007). For example, Silkos and Kerns (2007) examined the diagnostic process from first concern to diagnosis, in a sample of 56 children and teens with ASD. They found girls waited, on average, 1.5 years longer to receive a diagnosis, than what it took for boys. This was despite there being no difference in the number of medical professionals visited during the process, with parents accessing an average of 4.5 professionals. More recently, Begeer and colleagues (2012) investigated the timing of ASD diagnoses in a survey of over 2000 individuals with ASD. Results showed that for individuals less than 18 years of age, girls with Asperger's Disorder (where no intellectual or language impairment is evident) were diagnosed significantly later than their male counterparts. This was despite there being no difference in the timing of the age of the child when concern was first expressed. These findings particularly highlight the difficulty identifying the disorder in girls when intellectual disability is not present, potentially explaining why the diagnostic discrepancy is most pronounced at the cognitively-able end of the spectrum (i.e., in the absence of intellectual impairment). In particular, it suggests diagnosing the disorder in girls in the younger years is especially problematic. Why this may be the case will be explored in this thesis.

The impact of the diagnostic process on the diagnosis of girls. To understand how an autism diagnosis may be under detected in girls, the complexity of the diagnostic process must be acknowledged. Given the higher prevalence of boys diagnosed with ASD, much of our knowledge of ASD currently reflects the male presentation of the disorder. However, it has now been acknowledged in the DSM-5 that the disorder may present differently in girls (American Psychiatric Association, 2013). What we do not yet know is how these differences manifest. Broadly, there are three key factors that may be considered when deciding whether an impairment may be a sign of ASD, and thus may impact the diagnosis of girls. These are (1) the overt behaviours demonstrated by the child (e.g., obsessional interests, reduced eye contact, atypical motor movements), (2) the child's underlying understanding of social situations, and (3) the presence of impairments commonly associated with the disorder, such as impaired imitation. In various combinations, impairments in all of these areas potentially lead to the behaviour presentation of a child on the autism spectrum.

There are also a range of professionals who may be involved in deciding whether or not a child may be presenting with signs of ASD. The first professionals, to whom a parent would most likely express concern, are the family doctor or the child's teacher. These professionals are often not trained in the diagnosis of ASD, and thus may not have an understanding of the full spectrum of the disorder, let alone how it may present differently in girls. Consequently, these professionals may rely more on what they view as the 'typical' presentation of ASD, which may include the misconception that ASD is a 'boy disorder.' In the absence of a full diagnostic assessment, they would also likely rely more heavily on the overt behavioural presentation of the child, to judge whether an impairment may fit an ASD diagnosis. If these overt behaviours are different in girls, it may explain why the disorder is more difficult to detect. Because the

disorder is diagnosed so much less in girls, and given the behaviour presentation may be different, diagnostic clinicians and other professionals are likely to be far less experienced in how to identify the disorder in girls. Consequently, the diagnosis may be missed in girls, or, in those whose impairments do eventually becomes more salient, the diagnosis is delayed.

Do sex differences in the core symptoms of ASD explain why girls are diagnosed less? One reason ASD may be more difficult to identify in girls is that the core presentation of the disorder differs. Current knowledge on sex differences in the core symptoms of ASD provides inconsistent evidence on the potential role of explaining sex differences in the diagnostic rates. From the research, perhaps the more consistent finding regarding the core diagnostic criteria, is that fewer girls with ASD present with restricted interests, with this difference evident across toddlerhood, childhood, and adolescence (Hartley & Sikora, 2009; Lord, Schopler, & Revicki, 1982; Mandy et al., 2012; Szatmari, et al., 2012). Szatmari and colleagues (2012) found evidence to suggest females have a higher genetic liability to develop restricted and repetitive behaviours, explaining why girls may meet criterion for restricted interests less frequently than boys. However, clinical anecdote has suggested restricted interests are present in girls, but are different, thus potentially under-detected (Attwood, et al., 2006). However, the latter explanation is yet to be empirically explored.

Results for differences between the sexes are less consistent across the social and communication domains of ASD. When controlling for IQ, some studies show evidence of no sex differences in the social profiles of individuals with ASD, from toddlerhood to adulthood (Andersson, Gillberg, & Miniscalco, 2013; Dworzynski, et al., 2012; Holtmann, Bolte, & Poustka, 2007; Pilowsky, Yirmiya, Shulman, & Dover, 1998; Volkmar, 1993). These studies all included individuals with and without

comorbid intellectual impairment. When only cognitively-able individuals with ASD are included, some evidence still points to no sex differences in social impairment (Holtmann, et al., 2007). This includes a recent, larger scale study (n = 52 females, n = 273 males) that found no significant sex difference in social functioning of children and teens with ASD, based on a number of diagnostic assessments, including the Autism Diagnostic Observation Schedule (Mandy, et al., 2012). However, the literature also shows evidence of females with ASD having more severe communication and social deficits in childhood (Hartley & Sikora, 2009) and adulthood (McLennan, Lord, & Schopler, 1993). In further contrast, there is also evidence of less severe social and communication deficits in female adults diagnosed with high-functioning ASD (Lai et al., 2011). Our ability to draw conclusions across these studies has thus far been impacted by methodological issues including small samples of females (e.g., Andersson, et al., 2013; Pilowsky, et al., 1998) and the reliance on retrospective reporting after large time lapses (in some cases up to 40 years; Lai, et al., 2011). In Chapters 4 and 5, I have overcome these limitations, in particular with studies that engage larger samples of girls with high-functioning ASD, than what is currently seen in the literature. Further, when retrospective reporting was used (Chapter 4), I engaged a more restrictive age range to minimise the time lapse.

Given samples commonly focus on boys and girls who have already met criteria for ASD, it is perhaps not surprising that the research often fails to find evidence of significant sex differences in the core symptoms of the disorder. I argue that this information provides only limited insight into why girls are diagnosed both less and later at the cognitively-able end of the spectrum. For example, focussing on the core symptoms of ASD, for those already diagnosed in the pre-school years (Andersson, et al., 2013; Hartley & Sikora, 2009), can potentially only provide limited information on

how we may be missing girls during the pre-school years, as these early 'missed' girls would not be captured in the sample of early diagnosed children. Of interest to this thesis was moving away from exploring the core diagnostic criteria of ASD, to instead investigate the pre-diagnosis period, as well as how boys and girls come to meet the criteria. That is, what specific behaviours within each criterion led a clinician to provide that child with a positive diagnosis, and how may these more subtle differences make the diagnosis of girls more difficult? This provides more in-depth analysis of sex differences in the overt behaviours which may have been difficult for a medical professional or clinicians to identify. These studies also primarily focussed on those girls who, despite early concerns, were not diagnosed until school age, and thus also provides a more comprehensive insight in to potential reasons for why the diagnosis was not made earlier.

How girls with ASD present differently to boys: The role of behavioural presentation. The camouflage hypothesis provides an overview of how and why girls with ASD may present differently to boys (Attwood et al., 2006; Kopp & Gillberg, 1992; Wing, 1981). However, the hypothesis has largely remained embedded in clinical case studies (Kopp & Gillberg, 1992). The cornerstone of the hypothesis is the prediction that ASD is more difficult to identify in girls due to their ability to camouflage underlying impairments, primarily through imitating social interactions. This idea, proposed by Kopp and Gillberg (1992) more than two decades ago, was based on case studies of six girls with ASD, none of whom had an ASD diagnosis even considered until after six years of age, despite concern expressed to numerous medical professionals. Kopp and Gillberg noted that the girls tended to engage in imitation of speech and movement. Consequently, their social presentation seemed more typical than one would expect for ASD, despite the fact the girls were unable to understand

social rules. Further, the girls tended to be more clingy to people, rather than presenting as socially aloof. Drawing on these case studies and their own clinical experience, Attwood and colleagues (2006) further proposed ASD was more difficult to detect in girls primarily due their ability to mimic social interactions. This mimicking behaviour would mean underlying impairments often go unnoticed, at least until socialising becomes more complex in later childhood or adolescence. Importantly, the theory suggests girls with ASD experience comparable levels of underlying social impairments to boys with ASD, but behaviourally present differently.

Two recent studies have provided some empirical evidence for girls potentially engaging in strategies to hide their social impairments. Kothari and colleagues (2013) engaged a general population study and focussed on sex differences in children who were considered to have high autistic traits. The authors found girls high in autistic traits were better than their male counterparts at identifying facial emotions. In contrast to this, girls were just as impaired as boys in accurately identifying emotions from a novel social emotion recognition task. The authors suggested these findings may mean girls high in autistic traits are able to perform better on tasks where they could have learnt the behaviour (i.e., facial emotion recognition) but were equally impaired in their underlying social-emotion understanding (a task that could not be learnt). Similarly, Dworzynski and colleagues (2012) also engaged a general population sample, and drew on the Childhood Autism Spectrum Test (CAST) to explore the profiles of girls and boys who met criteria for ASD, compared to those who were just below the cut-off for meeting criteria. For those children who met criteria for ASD, the authors found that girls, compared to boy, were more likely to present with additional problems (e.g., lower intelligence and behaviour problems). Further, having these additional problems distinguished those children with ASD, from those just below the cut-off, for girls, but

not for boys. The authors suggested these findings may reflect girls' ability to engage in strategies that, in the absence of other significant behaviour and intellectual problems, hide the disorder. However, outside of these two population studies, there remains little evidence for if, how, and why, girls with ASD are able to hide their impairments.

The role of imitation. A female advantage in the imitation abilities of girls with ASD is the cornerstone of the camouflage hypothesis (Attwood, et al., 2006). That is, girls are said to be better at mimicking social interactions, which consequently may allow them to superficially camouflage their true social impairments (Kopp & Gillberg, 1992). Compared to typically developing children and those with other developmental delays, young children with ASD have consistently shown impairment in their ability to imitate the actions of others (Rogers, Hepburn, Stackhouse, & Wehner, 2003; G. S. Young et al., 2011). Indeed, whilst it is not considered a key diagnostic requirement, most early screening and diagnostic tools include information on imitation impairment (e.g., the Autism Diagnostic Observation Schedule; ADOS; Lord et al., 1989). Further, imitation training is also the focus of many early interventions, given its association with social competence in children with ASD and its role in early social learning (Rogers, et al., 2003; Sallows & Graupner, 2005). Case studies and anecdotal evidence suggest that girls with ASD present with better imitation skills (Kopp & Gillberg, 1992). However, as yet there is no empirical evidence regarding both sex differences in the imitation skills of children with ASD, as well as in the specific strategies (mimicking or otherwise) that girls with ASD use to navigate social situations. In chapters 4 and 5 of this thesis, using larger samples reporting on girls with ASD, I investigated whether girls were indeed more likely to engage in mimicking behaviour, compared to boys. This included information on parent report of imitation and information gathered from diagnostic clinicians' reports on children's and adolescents'

abilities to imitate for social gain. That is, I was not just interested in whether the child could or could not imitate, but rather whether the child showed evidence of generalising that imitation ability to a social context (e.g., copying others' interactions).

Differences in restricted interests. The camouflage hypothesis also proposed differences in restricted interests would further compound the difficulty in identifying ASD in girls (Attwood, et al., 2006). Attwood and colleagues (2006) suggested girls with ASD would typically present with different restricted interests that would be more difficult to determine as atypical. For example, a young girl with ASD may obsessively collect dolls, a behaviour which may be difficult to determine as atypical, and not considered a 'classic' presentation in ASD. This hypothesis suggests current evidence that females present with fewer restricted interests (e.g., Mandy, et al., 2012; Szatmari, et al., 2012) may be exaggerated due to the under-identification of restricted interests in girls. I have targeted this issue in the final two studies of this thesis, providing the first empirical exploration of sex differences in the types of restricted interests shown by girls and boys.

Sex differences in school presentation. Finally, the camouflage hypothesis also proposed girls would be particularly skilled in camouflaging their underlying lack of social understanding, when outside the home environment (Attwood, et al., 2006). Based on clinical experience, Attwood and colleagues (2006) suggested teachers would be less inclined to notice impairments in girls with ASD, as they would be less likely to cause behavioural disruptions in a classroom setting compared to boys with ASD. Specifically, Attwood and colleagues suggested girls would present in a school environment as introverted or withdrawn, and thus be less likely to draw attention to themselves and their difficulties, compared to boys who display more disruptive behaviours.

Until recently, this hypothesis also remained untested. However, two recent studies suggest teachers do indeed report fewer problematic behaviours for girls versus boys (Dworzynski, et al., 2012; Mandy, et al., 2012). To date, Mandy and colleagues (2012) have provided the most comprehensive investigation of sex differences in the home versus school presentation of children with ASD. Based on teacher responses on the Strengths and Difficulties Questionnaire, vast differences were found in the presentation of girls and boys with ASD when in the school environment. That is, teachers of girls were far less likely to report concerns than teachers of boys, including concerns with hyperactivity and peer relationships. This was in direct contrast to parent report, where more concern was reported for the emotional symptoms of girls compared to boys. That is, concern for girls did not appear consistent across settings. Girls presenting as less disruptive and with fewer peer problems, when at school, likely further compounds the difficulty of making an ASD diagnosis, given the impairments would not present consistently across settings. In this thesis I provide a further comprehensive exploration of the role of sex differences in the school presentation of girls and boys with ASD.

Summary

At the cognitively-able end of the autism spectrum, boys are diagnosed with ASD up to ten times more often than girls (Rivet & Matson, 2011). Evidence suggests this may not be a true estimate of prevalence, given the diagnosis of girls appears more problematic (Begeer, et al., 2012; Siklos & Kerns, 2007). However, as yet, we know little about why a sex discrepancy exists in both the prevalence and age of ASD diagnosis. This thesis explored two potential explanations for why ASD is diagnosed less and later in girls; (1) that girls may genuinely develop ASD less frequently than boys due to a typical advantage in the early development of factors associated with

social development and (2) that ASD may occur in girls more frequently than what is reflected in the diagnostic rates, but is under-detected in this population.

Contributions of the Thesis

Across this thesis I have made a number of contributions to the currently limited research on reasons for the sex difference in the prevalence and age of ASD diagnoses. First, I explored whether girls are protected from meeting ASD criteria as frequently as boys. This involved a more comprehensive exploration of the potential role of theory of mind development, with a particular focus on theory of mind abilities proposed to emerge prior to false belief understanding. Within this, I also provided an evaluation of a scale of theory of mind tasks that has the potential to provide a longitudinal assessment tool for early theory of mind ability as a construct (Peterson, et al., 2005). However, perhaps the largest contribution of this thesis is the exploration of reasons for why ASD may be more difficult to identify in girls. This included an exploration of sex differences in the specific factors that led parents to seek advice on their child's development, and an investigation into what specific strategies boys and girls reportedly used to manage social situations, prior to them receiving a diagnosis of ASD. Across the final two studies presented in this thesis I have also provided the first exploration of sex difference in the specific types of restricted interests displayed by children with ASD, to explore whether the restricted interests of girls may be more difficult to identify as atypical, thus further compounding the difficulty identifying the disorder. Finally, I provided the first exploration of how the newly proposed DSM-5 criteria impacts the diagnosis of ASD in girls, along with only the second comprehensive investigation of the role of teacher versus home presentation as a potential reason for the under-identification of the disorder in girls.

Structure of the Thesis

This thesis is arranged over 6 chapters, with the first having provided an introduction and overview of current knowledge on reasons for the sex difference in the rate and timing of ASD diagnoses. Chapter 2 of this thesis provides a brief overview of the current state of measures used to assess theory of mind, along with the validation of a five-item theory of mind scale (Peterson, et al., 2005; Wellman & Liu, 2004). Using this scale, Chapter 3 presents an empirical study of sex differences in typically developing children aged 2-5 years old. In this chapter I investigated whether there may be a female advantage in cognitive abilities which would result in greater early social competence, meaning girls would potentially be less likely to develop ASD. Chapters 4 and 5 present empirical studies of atypical populations. In chapter 4, I examined sex differences in the pre-diagnostic concerns for cognitively able children later diagnosed with ASD. Here the investigation was two-fold: First, I explored whether sex differences in pre-diagnosis concerns may provide insight into why it appears more difficult for girls to receive a diagnosis of ASD. Second, I was interested in whether girls and boys later-diagnosed with ASD engaged in different strategies to manage social settings. In my final empirical study, presented in Chapter 5, I explored sex differences in a population of children and adolescents with a current ASD diagnosis. Here, I explored numerous behaviours, based on DSM-5 criteria, that may (or may not) lead a medical professional to determine whether a developmental delay is indeed ASD. This chapter also includes a discussion on the impact of the new DSM-5 on the diagnosis of girls. Chapter 6 provides on overall discussion of the thesis findings, including how results can assist in developing a framework around improving the identification of ASD in females.

Chapter 2: Study 1a

The Validity and Scalability of the Theory of Mind Scale with Toddlers and Pre-Schoolers[2]

The past decade has seen a plethora of research assessing individuals' abilities to interpret the mental states of others, referred to as theory of mind. Essentially, this construct represents an individual's ability to not only understand the perspective of others, but to interpret that this may differ from their own, and how this perspective may influence the person's behaviour. Essentially, the construct represents one's ability to impute the mental states of both others and to the self (Premack & Woodruff, 1978). I was most interested in this cognitive construct due to it its association with social development (a core deficit in ASD; American Psychiatric Association, 2013). The extensive literature on theory of mind in late pre-school and early school years has consistently shown its importance for typical social development (C. Hughes & Leekam, 2004), including associations with peer rejection (Devine & Hughes, 2013), indirect aggression (Renouf et al., 2010), and prosocial behaviour (Caputi, et al., 2012). Further, theory of mind is considered a key cognitive deficit in individuals with autism spectrum disorder (Baron-Cohen, Tager-Flusberg, & Cohen, 2000).

Despite the importance of theory of mind for typical social development, there remain two key limitations that affect our ability to draw robust conclusions on the developmental role of this construct, including potential sex differences. First, there is a lack of evidence regarding the validity and reliability of theory of mind measures, with

[2] A large proportion of this chapter is currently under review at *Psychological Assessment*. Hiller, R. M., Weber, N., & Young, R. Short Report: The validity and scalability of the theory of mind scale for use with toddlers and pre-schoolers. *Psychological Assessment.* (minor revisions returned August 2013). [IF = 2.99]

some studies showing widely used theory of mind tasks have quite poor psychometric properties (L. Mayes, et al., 1996). The second concern is the continued focus in the literature on false-belief ability, as the sole measure of theory of mind (for similar critique see Burack, Charman, Yirmiya, & Zelazo, 2001). This focus contrasts with knowledge that theory of mind encompasses a range of abilities that begin to develop long before false-belief understanding (Wellmann, et al., 2001). Thus, the focus on a single theory of mind skill not only impedes our ability to understand theory of mind prior to four years of age, but also does not allow for the longitudinal assessment of theory of mind development. It also means there is currently little evidence of how early theory of mind may be measured, which would allow for the earlier identification of potential deficits in theory of mind which may go on to impact the child's social development. Of relevance to this thesis, the focus on false belief also impedes our ability to comprehensively understand sex differences in early, pre false-belief, theory of mind abilities. Given theory of minds apparent importance for social development, an early female advantage could have particular implications for the development of ASD.

In an attempt to provide a more comprehensive theory of mind assessment, Wellman and Liu (2004) proposed a theory of mind scale, consisting of five tasks designed to assess first-order theory of mind abilities. To form an adequate scale, the abilities measured were proposed to progress in difficulty and as such develop in a progression across early childhood. Further, Wellman and Liu proposed that a single score, calculated from the scale, could be used to index theory of mind ability. That is, from a given ability level it could be presumed all lower items had been answered correctly and all higher (more difficult) items were answered incorrectly. The authors' original analysis of 75 typically developing children showed 80% of respondents (aged

3.5 years to 6 years of age) provided response patterns where this index score (highest item scored correct) did indeed accurately reflect their performance. The usefulness of this task has been further demonstrated with both typically- and atypically-developing children, across numerous age ranges, from three up to thirteen years old (Peterson, et al., 2005; Peterson, Wellman, & Slaughter, 2012; Shahaeian, et al., 2011).

Despite the scale's promise, some important questions remain regarding both its practical application and psychometric properties. My aim was to address these gaps. First, the scale is proposed to provide a measure which assesses theory of mind skills that precede false-belief understanding. However, there is no evidence for the usability of the scale with children under 36 months of age, with the vast majority of research focussed on children over 42 months of age (when one would expect false-belief ability to emerge). Consequently, the primary aims of this research were to assess both the usability and scalability of the five items with children from two years of age. My third aim was to assess the validity of this test against a standard false-belief task (the Sally-Anne paradigm). Through the assessment of this scale with a younger age range, I aimed to provide insight into its usefulness as a single theory of mind test, paving the way for its use as a longitudinal measure, and, for the purpose of this thesis, its use for the assessment of sex differences in early theory of mind.

Method

Participants

Seventy typically developing pre-school children were recruited through advertising at local pre-schools and childcare centres. Participants were excluded if there was a suspected or known developmental delay. Of the 70 children for whom parental consent was obtained, two were unable to participate due to one child being ill and the second receiving a diagnosis of Autistic Disorder during the assessment period.

The 68 remaining children (boys = 41, girls = 27) were aged between 24 and 61 months (M = 44.81, SD = 10.82).

Theory of Mind Measures

Two separate measures were administered. One was the widely used single-item Sally-Anne false-belief task (see Baron-Cohen, Leslie, & Frith, 1985) and the other was the Australian adaptation of the five-item theory of mind scale (Peterson, et al., 2005). These tasks were proposed to be more suitable for less verbal children and use vocabulary with which Australian children are more familiar (e.g., 'biscuit' instead of 'cookie'; Peterson, et al., 2005). Each task included a control question, which assessed the child's basic understanding of the scenario, followed by a focal question, which assessed the theory of mind ability. Tasks were presented in order from proposed easiest (Diverse Desires) to most difficult (Hidden Emotion), with the Sally-Anne task administered last. Scripts for each task are presented in Appendix A.

Diverse desires. This task was designed to assess the concept that another's likes may differ from one's own. The child is presented with two pictures. One picture is of a carrot and one is of a biscuit. A puppet enters the scene and the script is as follows: "*Here is a girl. The girl wants her morning tea. Here are two foods, a carrot and a biscuit."* The pretest question is *"*Which do you like best?" Following the child's choice the examiner responds, *"That's a good choice! But the girl doesn't like [their choice]. She likes [opposite]. She loves to eat [opposite] best of all."* The test question is then posed to the child: "So now the girl can choose only one food. Which will she choose?" In this case the correct response is the opposite of what the child chose (i.e., if their favourite food was the biscuit, the correct answer would be carrot).

Diverse beliefs. This task was designed to assess the child's understanding that another person may think differently about the same situation. In this task the child is

presented with a picture of some bushes and a picture of a garage. A puppet enters the scene and the script is as follows: *"This man wants his cat. The cat is hiding. It could be in the bushes or it could be in the garage."* The child is then asked the pre-test question: *"Where do you think the cat is?"* followed by the script *"Well, that's a good idea. But the man thinks his cat is in [opposite]."* Finally, the test question is posed to the child: "*Where will the man look for his cat?"* The correct answer is the opposite to the child's original response (i.e., if the child would look in the bushes, the character would look in the garage).

Knowledge access. This task was proposed to assess the child's ability to judge another's knowledge of a situation. A closed chest of draws is displayed to the child, with the pre-test question of *"What do you think is in it?"* The child can give any answer or indicate that they are not sure. Following the child's guess they are told *"That's a good guess. Let's open it. Oh, look! There is a dog in!"* The drawer is opened to display a toy dog. The drawer is then closed and the child is asked *"So what is in the drawer?"* with the correct response being "dog." A doll then enters the scene and the child is told *"This girl has never seen this drawer before. She has never opened it."* The child is then asked *"So has she looked in this drawer?"* to determine their understanding of the scenario. Finally, the test question asked is *"Does the girl know what is in this drawer?"* The correct answer is that the girl does not know what is in the drawer.

False belief. This task is proposed to assess the child's ability to judge another's false beliefs about a situation. A Band-Aid box is displayed to the child and they are asked *"Here is a Band-Aid box, what do you think is in it?"* If the child does not answer immediately they are prompted with the script, *"What is usually in a box like this?"* Next, the assessor states *"let's open it! Oh! There is a pig in it!"* and then closes the

box. The child is then asked *"Okay, so what is in the box?"* to ascertain their understanding of the 'false' content. A character then arrives in the scene and the child is told *"Here comes a girl. She has never looked in this box"* followed by the question *"What does the girl think is in the box?"* The correct answer is 'Band-Aid.' The child is then asked *"Did she look in the box?"* with the correct answer being 'No.'

Hidden emotion. This task was proposed to measure the child's understanding that a person's facial expression does not always match their emotion. This is considered to be the most difficult task in the five item battery (Peterson et al., 2005; Wellman & Liu, 2004). The child is presented with a picture showing the back of a boy's head (i.e., the boy is facing away from the child). The script is as follows: *"Here is a boy [picture of back of boy's head]. The boy and his friends were playing. A girl teased the boy and the others all laughed. The boy did not laugh. He did not think it was funny. But the boy did not want the others to see how he felt. If they saw how he felt, they would call him a baby."* The child is then presented with a visual rating scale depicting 'happy', 'ok' and 'sad.' The child is asked the real-emotion question: "*How did the boy really and truly feel when everyone laughed and teased him?"* The correct answer is 'Sad' which the child can convey by verbalising 'Sad' or by pointing to the picture of the sad face. Next, the child is asked to apparent-emotion question: *"How did the boy try to look on his face when everyone laughed and teased him?"* The correct answer is either 'happy' or 'okay.' Finally, the child is asked to justify their response, with the question *"Why did he try to look [happy/ok]?"* The correct response is any response that shows an understanding of the story (e.g., 'he did not want the other children to tease him'). To receive a score of correct on this task the child must provide an appropriate justification for their answer.

Sally-Anne false-belief. This task (not from the five-item scale) is based on the traditional Sally-Anne theory of mind task, proposed to measure a child's ability to judge where a character will think an object is, based on the character's knowledge of the situation (Baron-Cohen et al., 1985). The character's knowledge is different from the child's own knowledge of the situation. Two distinct containers are placed on the table in from of the child. The child is then given a green ball to hold. A puppet ('Sally') appears and the child is told that the ball belongs to the puppet and that she is going to play with his friend. A second puppet ('Anne') then arrives and the two puppets throw the ball back and forth between them. Sally then takes the ball and places it in the red box and leaves the scene. Anne then opens the red box, takes the ball, moves it to the blue box, and leaves. Sally then returns to the scene. The child is asked the test question: *"Where does Sally think the ball is?"* The correct response is the place Sally left the ball originally. The control question is then asked: *"Where is the ball really?"* The correct answer is where the ball was moved to.

Procedure

All children participated in individual cognitive assessments in a quiet area of their childcare centre or kindergarten. I administered all tasks on a small table, sitting directly opposite the child. To maintain motivation, each child received a sticker following their participation in each task (regardless of performance). No child indicated they wished to cease participation in the tasks, which were all play-like in nature, and as such, all tasks were completed in one sitting for all participants.

The scale's five tasks were: (1) Diverse Desires (understanding that another's likes may differ from your own), (2) Diverse Beliefs (understanding that another person may think differently about the same situation), (3) Knowledge Access (ability to judge another's knowledge of a scenario), (4) False Belief (judging another's false-belief

about the content of a descriptive box), and (5) Hidden Emotion (understanding a person's facial expression does not always match their emotion). For all children the scale's items were delivered from easiest to most difficult.

Tasks from the theory of mind scale were administered and scored as they were by Peterson and colleagues (2005). All task responses (to both the control and focal questions) were coded as either correct (1) or incorrect (0). Children were able to provide either a verbal or non-verbal (pointing) response. For the child to receive a score of correct for each task, they were required to first respond correctly to the control question.

For scoring of the focal questions, interrater agreement was sought for the justification component of the Hidden Emotion task, where scorer judgment was required. Tasks one through four required unambiguous single-word or pointing responses for an answer to be considered correct (see Peterson et al., 2005). An independent rater coded Hidden Emotion responses for the entire sample, with 100% interrater agreement.

Results

My primary aim was to assess the validity and scalability of the five-item theory of mind scale for use with children from two years of age. Thus, I first examined the descriptive statistics to determine if the tasks were actually comprehensible to this younger age range (see Table 2.1). Children demonstrated comprehension of the control question for each of the first three tasks (Diverse Desires, Diverse Beliefs and Knowledge Access) by around two years of age. Indeed, the entire sample was able to correctly respond to the control question presented with task 1 (Diverse Desires). There was also evidence of children demonstrating an understanding of diverse desires and diverse beliefs theory of mind abilities from just after two years of age.

Table 2.1

Number of Children Who Passed the Control Question and Focal Question Along With Age (in Months) at Which Questions Were Passed or Failed

Task	*n* passed (% of *N*)	*M* Pass Age (*SD*)	Youngest Pass	Oldest Pass	Youngest Fail	Oldest Fail
	Control (Preliminary) Question					
Diverse Desire	68 (100)	44.08 (11.26)	24.00	61.00	-	-
Diverse Belief	66 (96)	44.56 (11.08)	24.00	61.00	26.00	31.00
Knowledge Access	44 (65)	49.32 (9.08)	27.00	61.00	24.00	53.00
False-Belief	42 (61)	50.43 (7.89)	32.00	61.00	24.00	53.00
Hidden Emotion	46 (68)	50.28 (7.37)	32.00	61.00	24.00	46.00
Sally-Anne	60 (88)	44.77 (11.36)	24.00	61.00	26.00	55.00
	Focal (Theory-of-mind) Question					
Diverse Desire	53 (78)	47.26 (9.86)	26.00	61.00	24.00	53.00
Diverse Belief	39 (57)	47.85 (9.42)	27.00	60.00	24.00	61.00
Knowledge Access	28 (41)	52.39 (6.36)	33.00	60.00	27.00	61.00
False-Belief	11 (16)	53.09 (4.06)	45.00	60.00	32.00	61.00
Hidden Emotion	9 (13)	55.56 (4.36)	46.00	60.00	32.00	61.00
Sally-Anne	29 (42)	53.17 (6.01)	37.00	61.00	24.00	56.00

Scale Analyses

I assessed the scalability of the tasks to determine the best index (i.e., highest item correct or total items correct) of theory of mind performance and to ensure the tasks remained scalable with this younger age range. To replicate the analyses used by

Peterson and colleagues (2005), scalability was assessed using Guttman (Green, 1956) and Rasch (Rasch, 1960) scale analyses. There are six patterns of responses consistent with scalable performance on the five items (see Table 2.2). These patterns reflect the key requirement of a scalable measure; that from a person's ability level all higher tasks should be incorrect and all lower tasks correct. Seventy-two per cent of the children in this sample responded in a pattern that mapped onto one of the six ordered patterns. Table 2.2 shows the percentage of children whose responses fit each possible pattern. The 'other' category on Table 2.2 represents response patterns that did not fit one of the scalable patterns. Of those children whose responses did not fit an exact scalable pattern, 74% (n = 14) gave an incorrect response followed by a correct response on the next highest item. This discrepancy did not appear to occur consistently for any specific item. The remaining five children (26%) from the 'other' category, received incorrect scores on two items below their highest success.

Table 2.2

The Six Scalable Response Patterns and Descriptive Statistics for Responses Fitting Them

Pattern	Diverse Desires	Diverse Beliefs	Knowledge Access	False Belief	Hidden Emotion	%(*n*)
1	-	-	-	-	-	16 (11)
2	+	-	-	-	-	13 (9)
3	+	+	-	-	-	19 (13)
4	+	+	+	-	-	16 (11)
5	+	+	+	+	-	5 (3)
6	+	+	+	+	+	3 (2)
Other						28 (19)

Note. + represents correct response, - represents incorrect response

Guttman analysis. A Guttman scale is the statistical name for a scale with responses that strictly follow the proposed ordered pattern. More specifically, it is a deterministic scale, and as such, is based on the assumptions that: (i) all items lower than an individual's ability level were scored correctly, and (ii) all items higher than the individual's ability level were scored incorrect. Green (1956) outlined two key statistics required to assess whether a series of tasks fit a scalable pattern. First, the coefficient of reproducibility represents the proportion of original responses which could be reproduced from the single item index, and must be over .90 for items to be considered scalable. Second, the coefficient of consistency indexes the extent to which observed scalability was greater than what is expected by chance alone, and must exceed .50 to be considered significant. The proposed five-item scale failed to meet criteria for a Guttman scale (index of reproducibility = .93, index of consistency = .41). However, a four-item scale (removing the most difficult 'Hidden Emotions' task) met criteria (index of reproducibility = .96, index of consistency = .60). As such, in a younger sample, a four-item, rather than five-item scale, provides a more suitable deterministic measure of theory of mind development.

Rasch analysis. A Rasch scale is the statistical name for a probabilistic scale that is less strict on the requirement of an exact ordered pattern. More specifically, it is based on the assumption that from a person's given ability level, the individual probably responded incorrectly to all higher items, and probably scored correctly for all lower items. The key difference between a Guttman- and Rasch-scale is that a Rasch scale not only allows, but predicts, some deviation from perfect ordering. Data were analysed using the WINSTEP computer program (Linacre, 2005).[3] From this analysis I examined

[3] Consistent with the methodology of Peterson and colleagues (2005), the item measures were rescaled to give the False Belief task an arbitrary item difficulty measure score of 5.0 on the scale.

both infit and outfit statistics for both item and person. Item fit statistics assess how well each item fit within the scale. The standardised infit statistic is more sensitive to responses that do not fit the pattern near a person's ability level (e.g., an incorrect score at a lower level than their ability). The outfit statistic is more sensitive to unexpected responses that are further away from the person's measurement level (e.g., an incorrect response to the easiest task and a correct response to the more difficult task). Both statistics have an expected value of 0 and a standard deviation of 1. Fit values of greater than 2.0 indicate the item is a misfit (Wright & Masters, 1982), and thus, does not fit with the proposed scale. A fit value of greater than -2.0 indicates overfit and thus suggests the scale is more deterministic than predicted by the Rasch model (making it a better fit for a Guttman scale). For the overall sample all item fit statistics met criteria, including the mean item fit for the overall scale (see Table 2.3), indicating the five tasks did indeed form an acceptable Rasch scale.

The output for a Rasch analysis also provides information on person fit. That is, how well each participant's response pattern fit the predicted scale order. As with item-fit statistics, for person fit statistics, a fit value of greater than 2 means the child's response pattern did not adequately fit with a probabilistic model. Only one child's fit statistic showed a pattern of responses that did not fit the statistical model, with a standard infit of 2.0. All other person infit and outfit statistics met criteria for a Rasch model, with an average infit of -0.1 (*SD* = 1.1) and average outfit of 0.0 (*SD* = 0.7; see Table 2.3). That is, the response pattern provided by all individuals, except one, was considered an adequate fit for the Rasch model.

Rasch analysis also produces item measure statistics that index the difficulty of each item (see Table 2.3). If the items were to form a scale, one would predict they would increase in difficulty in the proposed order. My analysis showed that the order of

observed difficulty matched the rank order of difficulty expected by the scale's authors (Peterson, et al., 2005; Wellman & Liu, 2004). However, the measure statistics of the two most difficult tasks (False Belief and Hidden Emotion) appear comparable in difficulty, suggesting why criterion was not met for the five-item Guttman scale. Specifically, based on the measure statistic, the two tasks differed in difficulty by only 0.12, less than half the standard errors of the estimates (0.28 and 0.29). The close difficulty level of these two tasks was also confirmed by the similar number of children who were able to pass the tasks (see Table 2.1).

The close measure scores of the two highest items may be due to a floor effect created by the inclusion of the younger sample (i.e., 2 – 3 year olds) who all failed both tasks. Thus, I also performed linear mixed model analysis to test the idea that the difficulty level of the tasks changed with age. I created a logistic mixed-effects model[4] with task outcome (passed or failed) as the dependent variable. Participant ID and item number were added as random effects (random effects ID SD = .52; item number SD = 1.64). Not surprisingly, the addition of age as a fixed effect significantly improved the fit of the model, $\chi^2(1) = 55.71$, $p = .001$, indicating the likelihood of a child passing the task increased as age increased ($b = .13$, $SE_b = .02$). However, allowing slopes to vary by participant did not improve the fit of the model $\chi^2(2) = 0.76$, $p = .68$. Therefore, there was no evidence of a significant difference in the difficulty trajectory of the items for the younger versus older children in this age range; meaning the similar difficulty levels of the highest two tasks were not due to the inclusion of the younger age range. However, I cannot rule out that the similar levels of task difficulty for the two hardest

[4] All mixed-effects models were created using the lme4 package (Bates, Maechler, & Bolker, 2011) in R, an open-source language and environment for statistical computing (R Development Core Team, 2011).

tasks may be due to the sample on the whole being younger than samples previously used by the scale's authors (e.g., with children up to 12 years old; Peterson, et al., 2012).

Table 2.3

Item and Person Measure Summary and Fit Statistics for Rasch Analysis of Five theory of mind Tasks

Tasks and Person	Measure	Error	Standardised infit	Standardised outfit
Item difficulty summary				
Hidden Emotion	5.12	.29	.0	-.3
Content False Belief	5.00	.28	.1	-.3
Knowledge Access	3.61	.23	-1.3	-.3
Diverse Beliefs	2.61	.25	1.5	1.3
Diverse Desires	0.86	.38	-.2	-.5
M	3.44	.29	.0	.0
SD	1.59	.05	.9	.7
Person ability summary				
M	2.93	1.14	-.1	.0
SD	1.67	.29	1.1	.7

Note. Expected values for standardised infit and outfit is $M = 0$ and $SD = 1$; a fit statistic > 2.0 indicates a misfit.

In sum, item fit statistics demonstrated good internal consistency between the five tasks, with all tasks fitting the Rasch model. These results, along with evidence of most children being able to pass the control questions on the easier tasks, provide

support for the suitability and usability of this scale with this younger age range. While there was evidence of the two highest tasks being equivalent in difficulty, this was not a result of the inclusion of toddlers but may have been due to the overall younger sample. Regardless, further analysis of the Guttman scale showed a four-item scale (excluding Hidden Emotion) was perhaps more appropriate for use with toddlers.

Convergent Validation

The Sally-Anne false-belief task is often considered the standard assessment of theory of mind (Bloom & German, 2000). Thus, performance on this task was used to assess the convergent validity of the theory of mind scale. Convergent validity was assessed by correlating the total number of tasks scored correct[5] with performance on the Sally-Anne task. A strong bivariate correlation ($r = .67$, $p < .001$) showed good convergent validity. As the total number of tasks scored correct increased, so did the likelihood of passing the Sally-Anne task. Thus, the theory of mind scale provides a score (total items correct) that strongly reflects performance on an already established theory of mind measure. However, the 45% of shared variance between the two measures clearly demonstrates that the measures are not redundant.

Discussion

Theory of mind is a key cognitive construct required for typical social development. However, I argued two key issues limited the ability to draw robust conclusions on theory of mind development, particularly in the pre-school years. The first was the paucity of empirical evidence on the psychometric properties of theory of mind measures and the second was the large focus on false-belief performance as the single indicator of theory of mind ability. These results provide the first demonstration

[5] Rasch person measure scores were not used as they correlated with the total items correct at a level of $r = .97$ ($p < .001$).

that the five-item theory of mind scale (Peterson, et al., 2005) is suitable for use with children from two years of age. Further, I found evidence that the five-items did form an adequate probabilistic (Rasch) scale. However, if a deterministic scale is required, a four-item scale is more advisable for use with toddlers.

Evidence of the suitability of this test for use with younger children was confirmed through two key findings. First, from two years of age, children showed comprehension of the scenarios presented in the easiest three tasks. Second, from two years of age some children showed evidence of Diverse Desires and Diverse Belief understanding, showing the usefulness of the scale in discriminating between the early theory of mind abilities of toddlers.

Further to its usability as a single theory of mind test, I found evidence of convergent validity of the five-item scale with the single-index Sally-Anne task. The strength of the correlation between these measures shows that scale score did indeed provide a score that could indicate performance on an alternate, widely used theory of mind measure. However, the fact the association was not perfect demonstrated the scale also provided a novel measure of early theory of mind, beyond what can be captured by a false-belief task alone. While the Sally-Anne task alone may remain suitable as a single test of false-belief for older pre-school and early-school aged children, the inclusion of the scale's earlier (easier) tasks clearly provide a more extensive examination of theory of mind, prior to the development of false-belief ability. Moreover, the Sally-Anne task may remain preferable in situations where a single index of false-belief performance in required, rather than a wider measure of theory of mind as a construct. This is particularly based on evidence that more children were able to pass the Sally-Anne task than the false-belief task presented in the scale. One potential

reason for this is that the Sally-Anne task is less verbal in nature than the task presented in the scale.

Practical Applications and Future Direction

To date, the focus on false-belief ability has restricted our assessment, and thus understanding, of early theory of mind ability. The confirmation of the scale's suitability with toddlers, opens an important window to more comprehensive examination of early theory of mind development. For this thesis, this primarily meant I had the ability to explore sex differences in early theory of mind ability, prior to when false-belief understanding would be expected to emerge. This was of importance, given a female advantage in early theory of mind may explain, at least in part, why girls develop ASD less frequently than boys.

For future research, outside of this thesis, the validation of this scale opens many other important avenues of research. Primarily, as the tasks were able to form a scale, it particularly demonstrates the strong potential of the use of this test as a longitudinal theory of mind measure. Wellman and colleagues (2011) have shown that patterns of responses evidenced in the scale's cross-sectional data are replicated longitudinally with late pre-school and school-aged children. Results of the current study now pave the way for the longitudinal investigation of this test in a much younger age range (i.e., from two years old).

Despite promising results, I acknowledge that this study employed a relatively small, culturally homogenous sample. Consequently, an important avenue for future research may be to focus on the use of this scale with larger samples of toddlers from different cultures (as has been done with slightly older samples; Wellman, Fang, Liu, Zhu, & Liu, 2006). Moreover, it is possible that performance on the scale may have been affected by such issues as concentration and motivation, particularly given the

young age range of the sample. That said, the use of sticker (rewards) charts and the short duration of each task were employed to minimise this issue.

Given theory of mind's link to social development, the future assessment of the test as a longitudinal assessment would also be highly beneficial in advancing our ability to early detect children who may be at-risk of developing social impairments. If we could identify what specific early theory of mind abilities (from the five-items) predicted later social difficulties it may open the window for identifying those children who may benefit from early social skills training, or even social support in the pre-school and early-school setting.

Summary

This study answered some important outstanding questions regarding the use and psychometric properties of the five-item theory of mind scale. The test was demonstrated to be suitable for children from two years of age. The test met requirements for a five-item Rasch scale, however, in a deterministic scale a four item scale was more appropriate for use with two- and three-year old children. Indeed, few two- and three-year olds were able to comprehend the scenario presented in the most difficult task (Hidden Emotion) and no child under 46 months showed this more complex theory of mind ability. The good internal consistency and convergent validity of the scale point to the usefulness of viewing the tasks as a single test of theory of mind, providing researchers access to a validated theory of mind test, which provides information across six levels of theory of mind performance.

Chapter 3: Study 1b

Sex Differences in the Cognitive and Social Skills of Typically-Developing Pre-Schoolers

Although it is known that cognitively-able boys are diagnosed with autism spectrum disorder (ASD) more frequently than girls, it is not currently understood if the sex difference in the diagnostic rates reflects a genuine difference or a difficulty identifying the disorder in girls, or indeed, a combination of the two. In this study I investigated whether sex differences in the development of certain cognitive abilities may account for a genuine difference in the prevalence rates. In particular, I explored whether girls may have better developed early theory of mind skills, which would be associated with better social competence, and thus, potentially, a reduced chance of developing ASD. Theory of mind was of primary interest due to its association with typical social development, and its frequently documented impairment in individuals with ASD (Frith, 1994; Senju, Southgate, White, & Frith, 2009). My second aim was to explore early sex differences in constructs associated with theory of mind development. This allowed me to explore potential reasons for why theory of mind may differ in typical development and whether girls may have an advantage in these abilities. By exploring sex differences in the cognitive, language, and social abilities of pre-school aged children, I have aimed to provide a comprehensive examination of whether girls may be genuinely less likely to meet criteria for ASD due to advantages in typical cognitive abilities related to social competence.

The primary aim of this study was to examine sex differences in the theory of mind ability of typically-developing pre-school aged children. Theory of mind is a cognitive construct defined as one's ability to interpret the mental states of others and determine how different states would affect that individual's behaviour (Wellmann, et

al., 2001). Theory of mind is considered a key cognitive impairment in ASD. This has led to the proposed 'theory of mind hypothesis' as an explanation for a range of behavioural deficits seen in individuals with ASD (Baron-Cohen, et al., 1985). The construct has been of interest to autism researchers due to its consistent association with social functioning. Typically developing children with greater theory of mind understanding have shown superior social functioning both in longitudinal (Caputi, et al., 2012; Watson, et al., 1999) and cross-sectional (Bosacki & Wilde Astington, 1999) research. For example, children who perform better on theory of mind tasks have been found to present as less aggressive and with more prosocial behaviour (Caputi, et al., 2012; Renouf, et al., 2010). Further, lower scores on theory of mind tasks in later childhood have been associated with an increased chance of peer rejection for boys and loneliness for girls (Devine & Hughes, 2013). Better developed theory of mind ability has also been associated with an increased likelihood of engaging in pretend play, an important part of early social development and where children learn many of the rules of social interaction (Lillard, 1993; Stagnitti & Unsworth, 2000). Given theory of mind is associated with social development, and social impairment is a key diagnostic criterion for ASD, I have hypothesised that a female advantage in theory of mind ability may protect girls from developing ASD as readily as boys.

The current literature on theory of mind provides no clear consensus on the existence of a potential sex difference. Research on typically developing children has provided some preliminary support for girls having superior theory of mind (Cutting & Dunn, 1999), with evidence of a female superiority in theory of mind in early childhood (Charman, et al., 2002; Walker, 2005), late childhood (Bosacki & Wilde Astington, 1999; Devine & Hughes, 2013) and adulthood (Baron-Cohen, et al., 1997). This includes a recent study that created a computerised version of the original Wellman &

Liu (2004) theory of mind scale (Calero et al., 2013). Here, with typically-developing children aged six to eight years old, girls demonstrated a slight advantage in performance on each of the scale's tasks. Charman and colleagues (2002) provided a systematic review on gender differences in false-belief ability, the most commonly used theory of mind paradigm. From exploring the extensive literature on theory of mind, it was concluded that there was evidence of a slight female advantage in girls' performance on false-belief tasks. However, this was only the case for younger (i.e., pre-school and early school aged) but not older samples. It was noted that, if a sex difference did indeed exist, it was a weak female advantage in false belief. However, since the publication of this review, there has also been contradictory evidence pertaining to no significant sex differences in theory of mind performance, from large scale longitudinal studies, measuring theory of mind across pre-school and early childhood (Caputi et al., 2012; Pellicano, Maybery & Durkin, 2005), and studies that have utilised the five-item theory of mind scale with young children (Peterson, et al., 2005; Wellman, et al., 2006; Wellman & Liu, 2004). Consequently, there remains little consensus on whether a true sex difference exists in theory of mind performance. Moreover, as outlined in Chapters 1 and 2, there remains significant methodological issues that mean it is currently difficult to draw comparisons between studies and determine whether a sex difference in theory of mind truly exists, particularly in the toddler and early pre-school years, prior to false belief development.

ASD is considered a pervasive developmental disorder (PDD), where signs of the disorder, including signs of social impairment, can often be retrospectively identified from infancy (Osterling & Dawson, 1994). Consequently, if theory of mind may protect girls from developing ASD it will be important to determine if a sex difference are evident from early in development. However, methodological limitations

have thus far impeded the ability to draw conclusions on sex differences in early theory of mind. This includes the paucity of knowledge on theory of mind abilities prior to expected false-belief development, and the lack of validated theory of mind measures, particularly outside of false-belief tasks. Consequently, to date, the majority of our knowledge on theory of mind comes from performance on a false-belief task, an ability that does not develop until later in the pre-school years. As such, we have little evidence of potential sex differences in theory of mind ability prior to the development of false-belief. In Chapter 2, I demonstrated the validity and scalability of the five-item theory of mind scale (Peterson, et al., 2005; Wellman & Liu, 2004). This allowed me to explore whether early theory of mind abilities, including those that precede false belief, would be better developed in girls, thus potentially explaining, at least partially, why girls develop ASD less frequently than boys.

The second aim of this study was to explore cognitive and environmental factors that might contribute to theory of mind development, and hence whether, if different between boys and girls, this may account for why girls may present with better theory of mind ability. Here, two specific areas were of interest: (1) the role of executive function and (2) the role of associated environmental influences on theory of mind. Both factors have been associated with theory of mind development (e.g., Pellicano, 2007; Ruffman, et al., 2002). However, again, we know little about whether or not associations exist between these factors and theory of mind, prior to the development of false-belief. Executive function was of interest here due to its association with theory of mind, and more specifically, evidence that it precedes later theory of mind development (Pellicano, 2007). Executive function is a cognitive construct comprised of three distinct abilities (Miyake, et al., 2000). These are ‘shifting’ (the ability to shift between tasks), ‘inhibition’ (the ability to inhibit inappropriate responses), and ‘updating’

(closely tied to working memory, being the ability to store and manipulate information in memory). All abilities develop during toddlerhood and the pre-school years (Garon, et al., 2008) and, like theory of mind, have been associated with social development (e.g., Olson, et al., 2005). If theory of mind was indeed advantaged in females, I was interested in whether this may be explained by a female advantage in executive function ability. That is, could better developed cognitive abilities, related to social development, explain why girls develop ASD less frequently than boys?

As outlined in Chapter 1, while there are numerous theories for the association between executive function and theory of mind (see Moses & Tahirogula,2009), recent evidence suggests executive function ability may be a prerequisite of theory of mind development. While cross-sectional research has suggested executive function may be important for later theory of mind (e.g., inhibitory controlling predicting deception ability; Hughes 1998) it is from longitudinal data where these associations are most usefully demonstrated. For example, Pellicano (2010), in a three-year longitudinal study of pre-school aged children with autism spectrum disorder and typically-developing children, found that early executive function predicted later theory of mind performance, but that the reverse was not true. This indicated support for the theory that executive function ability is a prerequisite for theory of mind development, with evidence of this directional association persisting in atypical (Pellicano, 2010) and typically-developing samples (Hughes, 1998; Moses, 2001).

Research has also demonstrated that the development of theory of mind can be sensitive to environmental influences (Perner, Ruffman, & Leekam, 1994; Ruffman, et al., 1999; Taylor, Carlson, Maring, Gerow, & Charley, 2004). In particular, it is apparent that children who are provided with more opportunity to take on other's perspectives (i.e., practice), can learn superior theory of mind understanding. For example, children

with a higher number of siblings, and thus essentially a constant play-mate, have demonstrated superior theory of mind understanding (Perner, et al., 1994). Perner and colleagues (1994) interpreted these results as demonstrating that the availability of siblings provides a rich 'practice ground' for children to practice and develop their understanding of the mental states of others (Perner, et al., 1994).Another area where children may be given the opportunity to practice perspective taking is through pretend play with peers. Pretend play is thought to be where children learn many of the rules that govern socialising (Stagnitti & Unsworth, 2000) and also potentially provides the child with an opportunity to take on the perspective of another character and attribute experiences to another character (see Lillard, 1993) . Given theory of mind's sensitivity to environmental influences, it may be that a female advantage in this cognitive construct is the result of girls being exposed more readily to environments that promote its development, potentially through both interactions at home and with peers.

Another such way children may develop advanced theory of mind is through exposure to perspective taking when interacting with parents. Specifically, more frequent references to mental states (mental state talk) by parents, when interacting with their child, is one such way that theory of mind is developed (Ruffman, et al., 1999; Ruffman, et al., 2002). These mental state utterances may include making reference to emotions, thought processes, or desires of themselves and others. Ruffman and colleagues' (2002) longitudinal analysis of mental state utterances and theory of mind provided the first longitudinal evidence for a positive association between parental use of mental state talk and children's later theory of mind.

Research has already demonstrated that parents of daughters, compared to parents of sons, use more frequent mental state utterances when conversing with their child (Cervantes & Callanan, 1998; Fivush, et al., 2000). Further, evidence suggests that

girls themselves use more mental state talk than young boys (C Hughes & Dunn, 1998). More specifically, Hughes and Dunn (1998) found that, at five years of age, girls both engaged in more mental state talk more frequently and used a wider variety of mental state utterances. As such, parents more frequent use of mental state talk with girls, may be due to the girls' advanced use of mental state language. Alternatively, girls' advanced mental state talk may be the result of increased exposure to parents' use of mental state talk. A longitudinal study by Taumoepeau and Ruffman (2008) provides support for the latter explanation, with their results finding early parent use of more complex mental state talk predicted later use of mental state talk by children. Therefore, a major focus of this study was the exploration of sex differences in mental state talk, as well as its association with a broader range of theory of mind abilities, including those theory of mind abilities said to precede false belief development.

The Current Research

This exploratory study focussed on the link between mental state talk, executive function, theory of mind, and children's social competence in a pre-school aged population. In particular I explored whether better cognitive abilities, and environmental differences, may be linked to girls' more advanced social competence, potentially protecting them from developing ASD. Based on current knowledge I theorised that theory of mind, executive function, and mental state talk may work together to provide females with a general advantage in their early social understanding. Specifically, I predicted that pre-school girls would perform better on theory of mind tasks, compared to boys, and that the association between sex and theory of mind would be partially mediated by executive function ability and exposure to mental state talk. Importantly, I predicted a female advantage in these abilities would be associated with girls' superior social competency. If these advantages were evident in typically-

developing girls, it may mean girls are better protected from developing ASD, where social functioning is a key impairment.

Method

Participants

This study used the same sample as study 1a (Chapter 2). The sample was comprised of 68 typically developing pre-school children (41 boys, 27 girls) aged between 24 and 61 months (M = 44.81 months, SD = 10.82).

Measures

Receptive vocabulary. The Peabody Picture Vocabulary Test – 4th edition (PPVT-4; Dunn & Dunn, 2007), was administered to all children, to provide a brief assessment of receptive vocabulary. The measure is considered a reliable and valid assessment of receptive vocabulary of pre-schoolers (Dunn & Dunn, 2007). The measure involves presenting the child with a series of sets, each comprised of four pictures. This child is asked to identify the correct picture based on the instructions (e.g., "put your finger on the picture that shows crying"). Raw scores were obtained for each child, according to the scoring procedure, as the age of the youngest children fell below the standardised sample. Based on raw score data, all children's receptive vocabulary was considered consistent with their chronological age.

Theory of mind tasks. As outlined in Chapter 2, the theory of mind tasks were taken from two sources. The full description of these tasks are presented in Appendix A and Chapter 2. Five of the 6 tasks comprised of the Australian version of the five-item scale of theory of mind development, taken from Peterson, et al. (2005). In order of proposed difficulty these tasks were: (1) Diverse Desires, (2) Diverse Beliefs, (3) Knowledge Access, (4) False Belief, (5) Hidden Emotion. All tasks included a control question, which assessed the child's understanding of the given scenario, followed by a

focal question to assess theory of mind. Abilities assessed by these five tasks are presented in Table 3.1. The literature has previously reported the overall scale performance as a continuous variable based on highest theory of mind item scored correct (e.g., Peterson, Wellman, & Liu, 2005; Wellman & Liu, 2004). However, with the younger age range the scale formed a probabilistic but not deterministic five-item scale (see Chapter 2). For this reason I have used total items scored correct (from 0 to 5) as the index of overall performance.

Table 3.1

Abilities Assessed by Each Task from the Five-Item Theory of Mind Scale

Task	Ability
Diverse Desires	Understanding another's likes may differ from your own
Diverse Beliefs	Understanding another person may think differently about the same situation
Knowledge Access	Ability to judge another's knowledge of a scenario
False Belief	Judging another's false-belief about the content of a descriptive box
Hidden Emotion	Understanding a person's facial expression does not always match their emotion

The sixth theory of mind task used was a traditional false belief task, based on the standard Sally-Anne task (Baron-Cohen, et al., 1985; Holroyd & Baron-Cohen, 1993). All children were presented with these tasks in an order ranging from simplest to most difficult, with the additional false-belief Sally-Anne task administered last. To receive a score of 'correct' for each task the child must have also answered the control question correctly. If the control question was answered incorrectly it was assumed that

the child did not understand the task. Thus, an 'incorrect' score on the theory of mind question may have represented a lack of understanding of the task, rather than the specific theory of mind ability. This system was utilised due to the verbal nature of the tasks and also aimed to minimise the chance that the child could simply guess the correct response. Both the control question and focal question were scored dichotomously (0 – incorrect, 1 – correct).

Executive function tasks. Five executive function tasks were administered to all participating children. The complete task descriptions and procedures are presented in Appendix B. These tasks were Spin the Pot (C. Hughes & Ensor, 2007), Tower of Hanoi (Carlson, Moses, & Claxton, 2004) A-not-B, Delayed A-not-B (Espy, Kaufmann, McDiarmid, & Glisky, 1999b), and Wrapped Gift (Carlson, 2005; Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996). Children's participation in the tasks was video-recoded to allow for later coding of the Wrapped Gift task (explained below). These tasks examined a range of components of executive function. Spin the Pot is proposed to tap in to working memory or updating, as is the A-not-B and Delayed A-not-B task, with the A-not-B tasks also shown to require inhibitory control (Espy, Kaufmann, McDiarmid, & Glisky, 1999a). The Tower of Hanoi task is a measure of planning ability. While planning ability is not specifically outlined in the previously discussed triad of executive function abilities (shifting, updating, inhibitory control; Miyake, 2002), it is widely considered an appropriate measure of executive function and has also been associated with such processes as working memory and inhibitory control (e.g., Hughes, 2002; Miyake et al., 2000; Pellicano, 2007). Finally, the Wrapped Gift task is a measure of inhibitory control and is also considered a 'hot' executive measure because of the affective component, present due to the task involving a potential reward for the

child (Hongwanishkul, et al.2005). All tasks have previously been used with pre-school samples (see Appendix B).

Spin the Pot, Tower of Hanoi, and the A-not-B tasks were all scored in terms of total trials scored incorrect (meaning higher scores equal worse performance). Spin the Pot consisted of a minimum of six and a maximum of 16 trials. The Tower of Hanoi task comprised 16 trials, while A-not-B consisted of 10 trials and Delayed A-not-B consisted of 20 trials. Trial number was based on previous research using these tasks (see Appendix B). Wrapped Gift was scored in two parts. Part 1 concerned their ability to stay with their back facing away from the examiner as the present was wrapped over a 1 minute period and was scored on a 1-5 scale (with 1 meaning the child turned around immediately and 5 meaning the child did not turn around; see Appendix B). Part 2 concerned the child's ability to refrain from touching the present while the examiner left the room for 2 minutes and was scored on a 1-3 scale (1 being the present was opened, 2 being the present was touched, and 3 being the child refrained from touching the present). Consequently, for Spin the Pot, higher scores represent better inhibitory control.

Mental state utterances. Interactions between the parent and child were video recorded and then later coded for both parent and child use of mental-state utterances. Mental-state utterances were coded into one of five categories: (1) emotions, (2) desires, (3) cognition, (4) assertion, (5) other. The coding manual was established based on the work of Bartsch and Wellman (1995), Ruffman et al., (2002), and Taumoepeau and Ruffman (2008). The transcribed interactions were coded for the frequency of references to each mental state category. This was used over the proportion of utterances, to remain consistent with previous coding of mental state talk (e.g., Ruffman et al., 2002). Parental mental state terms which were considered emotion utterances,

included all references to specific emotions (e.g., “happy”, “sad”, “worried”, “not pleased”). References to desire included such utterances as “want”, “like”, “hope”. Cognitive utterances included terms such as “think” and “know”. In line with previous coding of these utterances, the phrase “I don’t know”, where the child or parent did not elaborate on what was unknown, was not coded as a mental state term, because it might mean ‘I cannot answer’ (Ruffman et al., 2002; Bartsch & Wellman, 1995). Assertion utterances included words that modulated the certainty of a point, including “might”, “must”, and “possibly”. A final category, ‘others’ included references to other mental activities that did not fit one of the above categories (e.g., “remember”, “understand”, “forget” and “forgot”). Instances where the parent or child repeated the utterance, with no dialogue in between, were treated as self-repetition and were coded only as the single utterance. Using the same coding system, children’s use of mental state utterances were also coded for the ‘free-play’ portion. Children’s utterances were not coded for the ‘conversation’ component, as the general amount of utterances used by the child were substantially less frequent. That is, the parent tended to dominate the conversation. Inter-rater reliability was established across the five categories (emotion, desire, cognition, assertion and other), with adequate inter-rater reliability established (Cohen’s κ = .84 - .92).

Social function measures. Social measures were collected from parent- and teacher-report. The social section on the parent-report version of the Vineland Adaptive Behaviour Scale (VABS-II; Sparrow, Cicchetti, & Balla, 1989) was given to all participating parents to complete. The social domain on the VABS-II shows good internal reliability (r = .76 - .90) and test-retest reliability (r = .74 - .93) with pre-school aged children (see Sparrow et al., 1989). Further, the items on the social domain have been shown to correlate highly (r = .80) with the total scores on the overall measure,

and has shown good validity again other social measures (see Sparrow et al., 1989). The social domain of the VABS-II assessed three broad areas of social function: (1) interpersonal skills (e.g., social approach, interest in others), (2) play and leisure time (e.g., use of play time, cooperation skills), and (3) adapting (e.g., ability to manage change). With the current sample the social section of the VABS-II showed strong internal consistency, $\alpha = .86$, with scores on the three social areas (play and leisure, adaption, interpersonal skills) all correlated strongly with the overall social rating scores ($r = .77$ - $.85$).

The staff at each kindergarten or centre were also given an 8-item questionnaire, based on items from the VABS-II, that assessed factors considered important for children's social functioning. Teacher ratings of social abilities were provided on seven factors: (1) aggression, (2) dominance during play, (3) prosocial behaviour, (4) ability to use emotions appropriately, (5) number of friends (popularity), (6) interest in maintaining friendships, and (7) overall social ability. These ratings were made based on the staffs' opinion of how each child compared to same-aged peers. Staff circled the appropriate response for each question (e.g., Below Average, Average, Above Average, Far Above Average). As such, each behaviour was scored on a 1-4 scale. The scale showed acceptable internal reliability of $\alpha = .79$. The questionnaire also asked staff to identify the most common style of play preferred by each child. For this, the options were: (i) conversational pretend play (e.g., verbal role plays), (ii) non-conversational pretend play (e.g., putting dolls to bed, pushing trains around a track), (iii) physical play (e.g., running, climbing), (iv) solitary play (i.e., withdrawn), or (v) other. The complete staff questionnaire is presented in Appendix C.

Procedure

All children participated in the cognitive assessments in a quiet area of their childcare centre or kindergarten. I administered all tasks to children on a small table, sitting directly opposite the child. Where possible the battery of tests was administered in one sitting, preferably in the morning. In some instances, for younger children, more sessions were required. Where more sessions were required the theory of mind tasks were administered in session one (as per the procedure outlined in Chapter 2) and the executive function tasks in session two. For all executive function tasks, all children partook in the Spin the Pot task first, as it was considered the most engaging. Remaining executive function tasks were delivered in random order. To maintain motivation each child received stickers as a reward for completing each cognitive task.

The parent component, in which mental state talk was assessed during parent-child interaction, was implemented at the child's home. All children and their parent participated in two activities, which were video recorded. First, the parent was asked to engage their child in a ten-minute conversation about a pleasant event in which they had both participated. In line with procedure used by Bartsch and Wellman (1995) the event could not be the child's birthday and had to be recent enough for the child to remember. No further instructions were given in an aim to facilitate a naturalistic conversation. Second, the parent and child participated in ten minutes of free-play. This play could encompass any game that the child requested, in an aim, again, to capture a natural and typical home-play session for the child. If the child did not specifically request a game the parent was asked to choose a game that they knew the child enjoyed. Interactions were recorded for later coding. Where possible, the researcher was not present in the room when the recordings took place, to reduce distraction.

Statistical Analyses

I used logistic regressions, with sex as the outcome variable (boy – 0, girl – 1), for the majority of analyses. I was primarily interested in, regardless of developmental level, if performance on the variables of interest would predict the sex of the child. Consequently, age was controlled for in all regression analyses. Given age and receptive vocabulary were highly correlated (r = .86), only age was controlled for, due to issues of multicollinearity. Where I used hierarchical logistic regressions with categorical predictors, I used the regression equations to calculate the predicted odds for each level of all significant predictors. Odds ratios are asymmetrical around 1, meaning it is difficult to interpret odds ratios favouring girls (>1) with those favouring boys (<1). Consequently, I transformed all odds ratios to >1 and have noted whether the ratio favours girls or boys. All predicted odds ratios have also taken into account the higher proportion of boys in our sample. Specifically, ratios predictive of being a boy were multiplied by 0.65 (number of girls/number of boys; 27/41) while ratios predictive of being a girl were multiplied by 1.52 (number of boys/number of girls).[6] As such, results represent the predicted odds of being either a boy or girl, based on there being an even proportion of each sex.

To explore the presence of direct and indirect mediations, I used an INDIRECT SPSS MACRO based on bootstrapping procedure (Preacher & Hayes, 2008).

[6] The predicted odds ratios reflect the multiplication of the posterior odds (i.e., the sex ratio in the sample) and the information gained from the predictors. To ensure that the predicted odds reflected the information gained from the predictor – or, in other words, to calculate the predicted odds for a balanced sample of boys and girls – I multiplied the predicted odds by the inverse of the sex ratio (the posterior odds). Therefore, these corrected odds ratios are actually the diagnosticity index for the predictor variable in question; that is, they reflect the extent to which knowledge of the predictor changes our estimated odds that the child is a girl (or boy).

Bootstrapping analysis does not presume normal distribution or require a large sample size and is thus considered preferable over procedures such as the Sobel test. A resample procedure of 5,000 bootstrap samples was employed. Bias corrected 95% confidence intervals (CI) were also computed, with an indirect effect considered significant when zero is not contained within the interval. This analysis allowed me to explore a traditional mediation, as well as the presence of indirect mediations. An indirect effect can still be present, regardless of whether or not the predictor and outcome variable as directly associated (Preacher & Hayes, 2008).

Results

Theory of Mind, Age and Receptive Vocabulary

Theory of mind performance is strongly predicted by age and vocabulary (Happé, 1995) . This link was confirmed by the current study, with a strong positive association between receptive vocabulary and the number of control questions (r = .75) and number of focal questions (r = .70) scored correct. Moreover, as expected in a typical sample of children, receptive vocabulary was strongly associated with age (r -= .86).

The tasks used to measure theory of mind are often quite verbal in nature and thus require a certain level of language comprehension (Milligan, Astington, & Dack, 2007). As such, I first assessed whether girls and boys differed significantly on these factors. An independent samples t-test showed the average age (in months) of participating boys (M = 44.03, SD = 11.17) and girls (M = 45.88, SD = 10.46), did not significantly differ, $t(59) = -.66$, $p = .51$, $d = .12$. Likewise, there was no significant difference (with negligible effect size) between the average receptive vocabulary of boys (M = 72.03, SD = 31.04) and girls (M = 75.92, SD = 33.40), $t(65) = -.49$, $p = .63$, $d = .12$. As such, there is no clear evidence that any female advantage in theory of mind

ability could be explained by an advantage in receptive vocabulary or because girls were older.

Sex Differences in Theory of Mind

The primary aim of my study was to explore the presence of sex differences in the theory of mind abilities of pre-school children. The number and percentage of boys and girls who passed or failed each theory of mind task is presented in table 3.2. Logistic regressions were used to analyse sex differences in overall scale performance, as well as performance on each individual control question and focal question. Only those children who passed the theory of mind control question were included in the analysis. Age was controlled for in each analysis. Using sex (0 – boy, 1 – girl) as the outcome variable, I explored whether performance across each individual task could predict the sex of the child. Exploration of performance on the control tasks allowed me to examine whether sex differences were evident in the children's basic understanding of the scenario presented in each task. Sex differences in overall scale performance were also analysed using highest item correct. Table 3.3 shows results of regression analyses for each control question, while table 3.4 presents the results of the focal questions.

Table 3.2

Number of Girls and Boys who Passed or Failed the Theory of Mind Task After Passing the Control Question

	Girls		Boys	
Task	Pass *n* (% of *N*)	Fail *n* (% of *N*)	Pass *n* (% of *N*)	Fail *n* (% of *N*)
Diverse Desires	20 (74.1%)	7 (25.9%)	33 (80.5%)	8 (19.5%)
Diverse Beliefs	17 (65.4%)	9 (34.6%)	22 (55.0%)	18 (45.0%)
Knowledge Access	16 (76.2%)	5 (23.8%)	12 (52.2%)	11 (47.8%)
False Belief	4 (20.0%)	16 (80.0%)	7 (31.8%)	15 (68.2%)
Hidden Emotion	4 (100.0%)	0 (0.0%)	5 (83.3%)	1 (16.7%)
Sally-Anne	14 (60.9%)	9 (39.1%)	15 (40.5%)	22 (59.5%)

Five-item scale. Overall performance on the control questions failed to significantly predict sex, *Wald*(1) = 0.08, $p = .78$, *Exp(B)* = 1.09, 95% CI [0.60, 1.98]. Overall performance on the theory of mind questions also failed to significantly predict sex, *Wald*(1) = 0.52, $p = .47$, *Exp(B)* = 1.23, 95%CI [0.71, 2.13]. Consequently, there was no significant sex difference in the overall understanding of the scale (shown through response to the control question) or in overall theory of mind performance (based on responses to the focal questions). On average, girls passed 2.26 tasks (*SD* = 1.38), while boys passed an average of 2.00 tasks (*SD* = 1.34).

Looking at the individual control questions and tasks, control question performance for each individual task all failed to significantly predict sex (see Table 3.3). This indicated there was no significant difference in girls' and boys' understanding of the scenario presented in each task. For the individual theory of mind

questions, the only ability to significantly predict sex was task 3 (Knowledge Access; see Table 3.4). The predicted odds ratio showed if a child failed this task they were twice as likely to be a boy. This task was proposed to assess a child's ability to judge another person's knowledge of a situation (i.e., just because I know what it in the box, does not mean a new person would know). Over three-quarters of the girls (76%, n = 16) who passed the control question for task 3, went on to pass the theory of mind task (showing knowledge access ability). In contrast, only half of the boys (52%, n = 12) who passed the control question went on to pass the theory of mind component.

Additional false-belief task. I also used logistic regression analysis to explore whether performance on the additional Sally-Anne false-belief task would predict sex. Results are presented in Table 3.3 (control questions) and Table 3.4 (focal questions). After controlling for age, a significant sex difference was also evident for this task. Here, failing the Sally-Anne false-belief task predicted greater likelihood of being a boy. Of those children who passed the control question, 60% of girls (n = 14) compared to 40% of boys (n = 13) passed the false-belief question.

In sum, there was no sex difference in overall theory of mind abilities of pre-school children (based on the five item scale). However, performance on two of the six tasks (Knowledge Access and the additional Sally-Anne false-belief task) significantly predicted whether the child was a boy or girl. In both cases a female advantage was evident. This advantage was not due to girls demonstrating a better understanding of the scenarios presented (based on non-significant difference in response to control questions) and as such seems to be a genuine theory of mind advantage.

Table 3.3

Results of Logistic Regressions for Control Question Performance Predicting Sex, After Controlling for Age

Control Question[a]	Predicted Odds	*Wald*(*df*)	*p*	*ExpB* [95% CI]
Diverse Beliefs[b]				
Passed	1.03	0.21(1)	.64	1.99 [0.11, 36.69]
Failed (constant)	2.03	1.13(1)	.29	0.32 [0.04, 2.61]
Knowledge Access				
Passed	4.24	3.53(1)	.07	3.83 [0.92, 15.88]
Failed (constant)	1.08	0.10(1)	.76	0.71 [0.08, 6.30]
False Beliefs				
Passed	6.61	3.22(1)	.07	4.18 [0.88, 19.99]
Failed (constant)	1.48	0.001(1)	.97	1.04 [0.10, 10.70]
Hidden Emotion				
Passed	2.24	0.02(1)	.89	0.88 [0.15, 5.10]
Failed (constant)	1.97	0.78(1)	.38	0.33 [0.03, 3.86]
Sally-Anne False Belief				
Passed	2.17	0.55(1)	.46	0.56 [0.12, 2.56]
Failed (constant)	1.23	0.31(1)	.58	0.53 [0.06, 4.95]

Note. Underlined predicted odds ratios represent those variable levels predictive of being a girl. CI = confidence interval.

[a] All children passed the control question for task 1 (Diverse Desires), [b] Only 2 children failed the control question for task 2 (Diverse Beliefs).

Table 3.4

Results of Logistic Regressions for Focal (Theory of Mind) Question Performance Predicting Sex, After Controlling for Age

Task	Predicted Odds	*Wald*(1)	*p*	*ExpB* [95% CI]
Diverse Desires				
Passed	3.25	1.24	.27	0.45 [0.11, 1.85]
Failed (constant)	1.14	0.11	.74	1.22 [0.11, 1.85]
Diverse Beliefs				
Passed	1.12	0.41	.53	1.43 [0.48, 4.23]
Failed (constant)	1.25	2.41	.12	0.52 [0.84, 1.19]
Knowledge Access				
Passed	3.99	4.22	.04	5.05 [1.08, 23.69]
Failed (constant)	1.55	2.32	.13	0.42 [0.14, 1.27]
False Beliefs				
Passed	1.54	0.52	.47	0.59 [0.14, 2.48]
Failed (constant)	1.88	0.27	.60	1.24 [0.55, 2.75]
Hidden Emotion				
Passed	1.01	0.01	.95	1.06 [0.22, 4.98]
Failed (constant)	1.03	1.42	.23	0.63 [0.29, 1.34]
Sally-Anne False Belief				
Passed	10.72	2.02	.16	2.10 [0.66, 13.70]
Failed (constant)	5.11	4.65	.03	3.36 [0.14, .91]

Note. Underlined predicted odds ratios represent those variable levels predictive of being a girl. CI = confidence interval.

Was a female advantage in theory of mind associated with a female advantage in social competence? I hypothesised that a female advantage in theory of mind would be associated with greater early social competence, thus potentially acting as a protective mechanism for the development of ASD. Consequently, I also explored the association between theory of mind and social competence, based on parent and teacher ratings. Parents reported on their child's social functioning on the Vineland Adaptive Behaviour Scale (VABS-II) social domain. A number of parents incorrectly completed the VABS-II or failed to return it after repeated reminders, meaning completed questionnaires were available for only 35 children (17 boys, 18 girls). Where possible, information was collected for total score on the VABS-II (social domain), along with scores for the three social subscales (relating to others, play, and adaption). Teachers reported on various aspects of children's social skills on 4-point Likert scales (dominance, aggression, emotions, prosocial skills, friendships, maintaining of friendships, and overall social skills; see Appendix C).[7]

Before exploring associations between theory of mind and social competence, I used logistic regressions to determine if parent- or teacher-ratings of social competence would predict sex, after controlling for age. Results of parent ratings are presented in Table 3.5, while teacher ratings are presented in Table 3.6. I found no evidence that either parent or teacher ratings of social competency significantly predicted sex.

[7] Correlational analysis was used to test for multicollinearity. Number of friends 'popularity' and maintenance of friendships were strongly correlated with each other $r = .78$ and with overall social ratings, $r = .61$ and $r = .78$, respectively. No other items correlated above $r = .53$.

Table 3.5

Logistic Regression Results for Parent-Rated Social Skills Predicting Sex, After Controlling for Age

Social Skill	*Wald*(1)	*p*	*ExpB* [95% CI]
Total	1.62	.20	1.04 [0.98, 1.10]
Play and leisure	0.66	.42	1.06 [0.92, 1.23]
Adaption	0.87	.35	1.05 [0.95, 1.17]
Interpersonal skills	0.16	.69	1.02 [0.92, 1.14]

Table 3.6

Logistic Regressions for Teacher-Rated Social Skills Predicting Sex, After Controlling for Age

Social Skill	*Wald*(1)	*p*	*ExpB* [95% CI]
Overall	0.35	.56	1.21 [0.65, 2.24]
Dominance	2.36	.13	1.63 [0.87, 3.04]
Aggression	2.06	.15	0.54 [0.26, 1.23]
Emotions	0.19	.66	0.86 [0.44, 1.69]
Prosocial	0.24	.62	1.24 [0.53, 2.89]
Popularity	0.51	.47	1.28 [0.65, 2.52]
Friendships	0.80	.37	1.31 [0.73, 2.37]

Next, I used partial correlational analyses (with age controlled for) to explore the associations between performance on each theory of mind task, and ratings of social competency. Results are presented in Table 3.7. Results showed few significant associations between the variables, including those tasks where a female advantage was

evident (Knowledge Access and Sally-Anne false belief). On the Knowledge Access task the only social skill significantly associated with task performance was teacher-rated aggression. Here, increased aggression was moderately associated with an increased likelihood of failing this task (which assesses understanding that another person does not necessarily have the same knowledge as the child). No social rating from either teacher or parent report was significantly associated with performance on the Sally-Anne task (where a female advantage had also been found).

Table 3.7

Results of Partial Correlations, After Controlling for Age, Between Theory of Mind Tasks and Social Competency

	r						
	Diverse Desires	Diverse Beliefs	Knowledge Access	False Belief	Hidden Emotion	Scale Total	Sally-Anne
Parent							
Overall	-.14	.03	.22	.01	.35	.02	.22
Play	.11	.04	.21	.01	.20	.22	.02
Adaption	-.32	-.04	.05	-.03	.22	-.02	.33
Relating	-.10	.04	.34	.08	.43*	.33	.19
Teacher							
Overall	.11	.01	.02	-.04	.02	.04	.07
Dominance	.01	-.03	-.26	.07	.06	-.10	.18
Aggression	.13	.09	-.60**	-.02	.02	-.20	.001
Emotions	.19	.36	-.30	-.10	-.11	-.01	.17
Prosocial	-.12	.10	.20	-.05	-.12	.04	.32
Popularity	.01	.25	-.19	-.19	.09	-.02	.07
Friendships	.29	.12	.05	-.13	-.05	.09	.25

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

Did theory of mind performance mediate an association between sex and social competence? While there were few associations between the theory of mind task performances and social ratings, I remained interested in whether performance on the theory of mind tasks, where a female advantage was evident, would mediate an association between sex and social functioning. I used a boostrapping procedure to

explore these mediations (Preacher & Hayes, 2008). As theory of mind and social competence were largely not directly associated, I was primarily interested in whether theory of mind may indirectly mediate an association between sex and social competence. That is, might an association between being female and passing the Knowledge Access and Sally-Anne task, indirectly result in greater social competence?

For the purpose of this analysis sex (0 – boy, 1 – girl) was the predictor variable, theory of mind performance (on either Knowledge Access of Sally-Anne false belief) was the mediator (0 – failed, 1 – passed) and the social skill of interest was the outcome variable. Overall social rating on the VABS-II was used as the outcome variable for ease of analysis, as it was strongly correlated with the three social components (r = .77 - .85). Theory of mind performance on both tasks (Knowledge Access and Sally-Anne) failed to mediate an indirect association between sex and any parent rating of social functioning. Further, performance on the Sally-Anne false belief task also failed to mediate an indirect association between sex and any teacher rating of social skills.[8]

However, there was an indirect effect of sex on two teacher rated social skills, mediated by performance on the Knowledge Access task. These were aggression and prosocial behaviour. For the aggression model, girls were more likely to pass the Knowledge Access task, B = .36, SE_B = .12, p = .004, and passing this task was associated with less aggression, B = -.60, SE_B = .18, p = .001. While sex and aggression ratings were not directly associated, B = -.30, SE_B = .18, p = .10, there was evidence of a significant indirect association, B = -.22, SE_B = .10, 95% CI [-0.48, -0.07]. As such, being a girl was associated with an increased chance of passing the Knowledge Access task, which, in turn, was associated with lower teacher-ratings of aggression. Similar results were evident for prosocial skills. While sex (predictor) was not directly

[8] Results for the Bootstrapping indirect associations can be found in Appendix E.

associated with prosocial skills, $B = .11$, $SE_B = 16$, $p = .48$, an indirect association was again evident, $B = .14$, $SE_B = .08$, 95% CI [0.03, 0.36]. That is, increased likelihood of being a girl, was associated with increased likelihood of passing the Knowledge Access task. Passing this task was in turn associated with higher teacher ratings of pro-social skills.

To summarise, I found little evidence of associations between theory of mind and social skills. However, I did find that the female advantage in the Knowledge Access theory of mind ability mediated an indirect association between sex and both aggression and prosocial skills. That is, being a girl was associated with an increased chance of passing the Knowledge Access task, which in turn was associated with higher ratings of prosocial skills and lower ratings of aggression, when at pre-school.

Was theory of mind associated with play preference? Outside of social competency ratings, I was also interested in associations between theory of mind and a preference for pretend play. This was of interest based on evidence that role play pretend play games are where children learn many rules of social interactions. To examine this, teachers reported on the child's play preference when in the pre-school environment, based on a list of potential options (conversational pretend play, non-conversational pretend play, physical play, solitary play, and other). Before exploring the association between theory of mind and play preference, I used a chi square analysis to explore general sex differences in play preferences. [9] Results showed significant sex differences in children's preferences for play, $\chi^2(4) = 17.25$, $p = .002$, (phi) $ø_c = .53$. The vast majority of girls in our sample (75%, $n = 18$) showed a primary preference for verbal pretend play (i.e., role plays), while this was the preference for only 26% ($n =$

[9] Chi square analysis, rather than a logistic regression, was used for this analysis because the low number of observations in many cells meant the logistic model would not converge appropriately.

10) of boys. A third of boys (32%, *n* = 12) showed the strongest preference for physical play. Very few children preferred 'other' types of play (including solitary; girls: 4%, *n* = 1; boys:13.2%, *n* = 5). The remaining 29% of boys and 21% of girls preferred non-conversational pretend play (e.g., pushing trains around, brushing the dolls hair).

Given evidence of a strong female preference for role play games, I was interested in whether this preference (versus a preference for any other types of play) would be associated with theory of mind ability. As such, teacher responses were recoded to a dichotomous variable (verbal pretend play v other). I used logistic regressions to explore whether theory of mind performance on the Knowledge Access and Sally-Anne false belief tasks would predict a preference for pretend play, after controlling for age. Preferred play style (0 – pretend play, 1 – other types of play) was used as the outcome variable and theory of mind performance (0 – fail, 1 – pass) was the predictor. After controlling for age, passing the Knowledge Access task significantly predicted play preference, *Wald*(1) = .01, *Exp(B)* = 30.01, *p* = .01, 95% CI [1.99, 450.34]. Passing the Sally-Anne false-belief task also significantly predicted play preference, *Wald*(1) = 7.23, *p* = .01, *Exp(B)* = 52.11, 95% CI [2.92, 925.19]. In both instances, passing the task was associated with an increased likelihood of preferring pretend-play.

While performance on both the Knowledge Access and Sally-Anne false belief task both predicted play preference, the upper limit of the confidence intervals were extremely large. This is likely because controlling for age removed much of the relevant variance in play preference, thus reducing the stability of the coefficient estimates. That is, older children would have been more likely to pass the tasks and would also have been more likely to engage in the more complex role play style games. Consequently, I also analysed the data with the inclusion of only the younger children. Specifically, I

included only children aged below 3.5 years old, where one would expect more variability in the pass and fail rates of the Knowledge Access and Sally Anne false belief task. Age was not controlled for in the analysis. Results of the logistic regressions showed performance on the Knowledge Access (p = .32) and Sally Anne false belief task (p = .69) both failed to predict play preference (pretend play v other types) in this younger age range. As such, the significant association between performance on these tasks and an increased likelihood to prefer pretend play, appears to largely be an artefact of increased age, with older children having an increased likelihood of passing the task, and a preference for more complex pretend play.

Sex Differences in Executive Function

Beyond the associations between sex, theory of mind, and social competence, the second area of interest to this study was exploring sex differences in variables shown to be associated with early theory of mind development. I originally predicted that girls' better developed theory of mind ability may stem from better developed executive function ability. As such, my interest in executive function was two-fold: (1) would there be a female advantage in executive function ability, and (2) was executive function ability associated with theory of mind? First, I explored whether sex differences were evident in any of the five executive function abilities I measured. Descriptive statistics for the average performance of boys and girls on each task are presented in table 3.8. I again used logistic regressions to explore whether performance on each executive function task would predict sex. See Table 3.9 for results of logistic regressions. After controlling for age, results showed no evidence that performance on any of the executive function tasks significantly predicted sex. This included no evidence of a sex differences on Wrapped Gift performance, which was the executive function task considered to involve an affect element.

Table 3.8

Average Performance of Boys and Girls on the Executive Function Tasks

Task	Girls *M* (*SD*)	Boys *M* (*SD*)
Spin the Pot	2.23 (3.42)	2.76 (3.14)
Wrapped Gift (wrapping)	3.17 (1.61)	3.11 (1.59)
Wrapped Gift (waiting)	2.74 (0.45)	2.52 (0.51)
Tower of Hanoi	9.27 (4.05)	10.42 (4.04)
A-not-B	1.69 (1.22)	2.44 (2.11)
Delayed A-not-B	7.23 (3.71)	7.54 (2.64)

Note. Spin the Pot, Tower of Hanoi, A-not-B and Delayed A-not-B, scores represent average number of errors (higher scores = worse performance). For Wrapped Gift, higher scores represent better performance, with the wrapping phase scored on a scale of 1 to 5 and the waiting phase scored on a scale of 1 to 3 (see Appendix B).

Table 3.9

Results of Logistic Regressions for Executive Function Performance Predicting Sex, After Controlling for Age

Task	*Wald*(1)	*p*	*Exp(B)* 95% CI
Spin the Pot	0.02	.88	0.98 [0.81, 1.20]
Wrapped Gift (wrap score)	0.03	.86	0.97 [0.65, 1.42]
Wrapped Gift (wait score)	2.09	.15	0.39 [0.11, 1.39]
Tower of Hanoi	0.37	.54	0.94 [0.78, 1.14]
A-not-B	1.99	.16	0.79 [0.56, 1.10]
Delayed A-not-B	0.002	.96	1.01 [0.84, 1.21]

Note. Scores on Spin the Pot, Tower of Hanoi, and both A-not-B tasks represent total number of errors made on task.

Was executive function associated with theory of mind? Next, I investigated whether executive function performance would be associated with overall theory of mind ability. Linear regressions assessed whether performance on any of the executive function tasks would predict overall performance on the five-item theory of mind scale. Total number of items correct (from 0 to 5) was used as the theory of mind outcome variable. Table 3.10 presents results for all executive function tasks. The only executive function task to predict overall theory of mind performance was the Tower of Hanoi task. On this task, which assessed children's planning ability, fewer incorrect planning decisions was associated with higher scores for the total item of theory of mind tasks scored correct. That is, after controlling for age, poorer planning ability was significantly associated with poorer theory of mind performance. However, performance on this planning task explained only 7% of variance in children's overall theory of mind performance.

Table 3.10

Results of Linear Regressions for Executive Function Predicting Overall Theory of Mind Ability, Controlling for Age

Task	F_{change}	*df1, df2*	*p*	R^2_{change}
Spin the Pot	0.02	1, 64	.89	<.001
Wrapped Gift (wrap score)	1.64	1,59	.21	.01
Wrapped Gift (wait score)	0.03	1,41	.86	<.001
Tower of Hanoi	11.21	1,64	.001	.07
A-not-B	2.08	1,64	.16	.01
Delayed A-not-B	1.02	1,64	.32	.01

Finally, I used partial correlations (controlling for age) to explore associations between the executive function tasks and individual theory of mind task performance. The correlation matrix is presented in Appendix D. There was little evidence that executive function ability was associated with those theory of mind tasks where a female advantage was evident (Knowledge Access and Sally-Anne false-belief). There were potentially some evidence of trends (e.g., Knowledge Access and Spin the Pot, r = -.26, p = .09), meaning the lack of significant associations may be due to a power issue. However, given the risk for type 1 error, and the low variance explained in the association, I would be cautious to draw associations between performance on the tasks. In sum, in contrast to predictions, I found no evidence of significant sex differences in the executive function abilities of pre-school children, including evidence of significant associations between performance on the executive function tasks and theory of mind tasks.[10]

Mental State Talk

Mental state talk was the second associated construct of interest, due to its link with theory of mind development. Again, I was interested both in sex differences in mental state talk, as well as its association with theory of mind. Mental state talk was proposed to be a useful part of early child development, by providing children with exposure to perspective taking. Consequently, I was interested in exploring whether a female advantage may be evident for how frequently children are exposed to this type of talk, when engaged in conversation with parents.

[10] It was originally proposed executive function would mediate the association between sex and theory of mind. However, based on no robust evidence of sex differences in executive function, or of associations with theory of mind, this cognitive construct was not further explored.

Before analysing sex differences in use of mental state talk, I used an independent samples t-test to ensure there was no significant difference between the amount of speech used during interactions, for parents of daughters versus parents of sons. No significant difference was found $t(42) = -.41$, $p = .68$, $d < .01$, meaning it is likely any sex differences were not due to parents of girls simply being more verbose. Parents used an average of 0.73 (*SD* = 1.37) emotion utterances during the interaction, 8.51 desire utterances (*SD* = 5.96), 8.47 cognitive utterances (*SD* = 5.64), 2.42 assertion utterances (*SD* = 2.78) and 6.31 'other' utterances (*SD* = 4.96). Children used an average of 0.04 (*SD* = 0.21) emotion utterances during the interaction, 2.52 desire utterances (*SD* = 2.67), 1.85 cognitive utterances (*SD* = 2.44), 0.63 assertion utterances (*SD* = 1.06) and 0.30 'other' utterances (*SD* = 1.05). I used logistic regressions to assess whether frequency of mental state talk could predict sex. Results are presented in Table 3.9. Significant sex differences (favouring girls) were found in both parent and child use of mental state talk. In free conversation parents' higher overall use of mental state utterances predicted increased likelihood of the child being a girl, rather than boy. Further, more frequent use of utterances associated with cognitions (i.e., utterances pertaining to how one's self of others may think) and assertions (i.e., markers of certainty, such as 'must' or 'might') both predicted a higher likelihood of being a parent of a daughter (rather than parent of son).

Significant sex differences were also evident in children's own use of mental state talk (also presented in Table 3.11). Higher use of overall mental state utterances and desire utterances (e.g., 'like', 'love', 'want') were both associated with an increased likelihood the child was a girl rather than boy. As such, as predicted, I found evidence that girls used, and were exposed to, a higher frequency of mental talk.

Table 3.11

Logistic Regression Results for Frequency of Mental State Talk Predicting Sex, After Controlling for Age

Utterance Type	*Wald*(1)	*p*	*Exp(B)* 95% CI
Parent			
Total	4.66	.03	1.09 [1.01, 1.17]
Emotion	2.85	.09	1.60 [0.93, 2.68]
Desire	0.28	.60	1.03 [0.93, 1.14]
Cognition	5.34	.02	1.17 [1.02, 1.34]
Assertion	4.21	.04	1.38 [1.01, 1.87]
Other	0.49	.48	1.05 [0.93, 1.18]
Child			
Total	4.55	.03	1.21 [1.02, 1.43]
Emotion	0.01	.95	1.10 [0.06, 19.11]
Desire	5.03	.03	1.50 [1.05, 2.15]
Cognition	0.17	.68	1.05 [0.82, 1.35]
Assertion	0.94	.33	0.73 [0.39, 1.38]
Other	1.49	.22	2.54 [0.57, 11.39]

Note. CI = confidence interval.

Sex, mental state talk, and theory of mind. Based on evidence that girls are exposed to, and use, more frequent mental state talk, I was interested in whether these utterances may mediate an association between sex and theory of mind. In particular, I was interested in whether an indirect association (mediated by mental state talk) may explain a female advantage in theory of mind. That is, if females are exposed to more

frequent mental state talk, could this exposure, in turn, be associated with better theory of mind. To explore this I used bootstrapping analysis (Preacher & Hayes, 2008). This allowed me to explore the presence of an indirect effect between sex, mental state talk, and theory of mind. A resample procedure of 5,000 bootstrap samples was employed. Bias corrected 95% confidence intervals (CI) were also computed, with an indirect effect considered significant when zero is not contained within the confidence interval. For the purpose of this analysis total number of mental state utterances (used by the parent) was used as the mediator, with total items correct from the theory of mind scale used as the outcome variable. Sex was used as the predictor variable (coded as 0 – boy, 1 – girl).

As expected, sex was significantly associated with mental state talk, $B = .29$, $SE_B = 3.47$, $p = .04$ but not directly associated with overall theory of mind, $B = -0.03$, $SE_B = 0.39$, $p = .65$. However, mental state talk was also not directly associated with theory of mind, $B = .02$, $SE_B = .02$, $p = .23$. There was no evidence of a significant indirect effect of sex on theory of mind, through mental state talk, $B = .14$, $SE_B = .12$, Bootstrapping 95% CI [-0.01, 0.47]. However, the lower limit of the confidence interval, which sits only just below zero, suggests the indirect association is potentially approaching significance. Consequently, the lack of a significant indirect association may be due to the study being underpowered.

Individual utterances and theory of mind tasks. While overall use of mental state utterances failed to directly or indirectly mediate an association between sex and theory of mind, I was also interested in exploring whether specific theory of mind tasks would be associated with specific types of mental state utterances. I used partial correlation analyses (controlling for age) to explore associations between the individual

theory of mind tasks and utterance types. Results are presented in Table 3.12 (task performance was coded as 0 – failed, 1 – passed).

Regarding parent use of mental state talk in conversation, increased emotion utterances were the only type significantly associated with the child's theory of mind ability. However, no sex difference was evident for this type of utterance. Further, regardless of the sex of the child this type of utterance was used rarely by parents. For child use, no type of utterance was significantly associated with their overall theory of mind ability.

For the Knowledge Access theory of mind task (where a female advantage was evident) parent use of cognition utterances and overall utterances were moderately associated with correctly responding to the Knowledge Access task (r = .30 - .31, p = .04). For both of these utterances a significant sex difference was evident (see Table 3.11). Again, the child's use of utterances was not associated with performance on the Knowledge Access task. As such, parents exposing girls to more frequent examples of perspective taking in conversation, and more specifically, the concept that others may think differently from themselves (cognitive utterances), may partially explain why girls have an advantage in their knowledge access ability. However, when this was tested in a bootstrapping model, the predicted indirect association was not found, B = 0.43, SE_B = 0.41, Bootstrapping 95% CI [-0.04, 1.57]. As such, while cognitive utterances and Knowledge Access performance were moderately associated, cognitive utterances did not significantly directly or indirectly mediate the association between sex and Knowledge Access theory of mind ability. However, again, the lower limit of the confidence interval suggests this indirect association may be approaching significance.

Finally, for performance on the Sally-Anne task (where a female advantage was also found), results reflected those for overall theory of mind performance. That is,

parent use of emotion utterances was the only type of utterances associated with performance on this task. Increased use of this utterance was associated with increased chance of correctly responding to the Sally-Anne false-belief task. As emotion utterances, regardless of sex, were so rarely used in this age group, no further analyses were performed on these associations.

To summarise, I found evidence of a female advantage both in the use of, and exposure to, mental state talk. Further, parent (but not child) use of mental state talk was weakly to moderately associated with increased likelihood of passing the Knowledge Access theory of mind task (where a female advantage was also evident). It was predicted increased exposure to mental state talk may mediate the association between sex and Knowledge Access performance. Bootstrap analysis suggested these associations may exist, however, potentially due to a power issue, results showed no evidence of a significant indirect association. Mental state utterance exposure did not significantly mediate (either directly or indirectly) the association between sex and theory of mind (including Knowledge Access). Consequently, I cannot conclude that girls' increased exposure to mental state utterances explained the female advantage in performance on the Knowledge Access task.

Table 3.12

Partial Correlations, Controlling for Age, Between Frequency of Types of Mental State Utterances and Overall Theory of Mind (ToM) and Knowledge Access Performance

	Overall ToM		Knowledge Access		Sally Anne	
Utterance Type	*r*	*p*	*r*	*p*	*r*	*p*
Parent use						
Emotion	.34	.02	.21	.17	.36	.01
Desire	.05	.76	.02	.89	.02	.89
Cognition	.15	.31	.30	.04	.20	.19
Assertion	.17	.27	.16	.29	.25	.10
Other	.03	.86	.25	.10	.13	.40
Total	.17	.25	.31	.04	.25	.10
Child use						
Emotion	-.07	.65	.20	.17	-.02	.90
Desire	.02	.89	-.16	.30	.07	.67
Cognition	.06	.66	-.01	.97	-.02	.89
Assertion	-.02	.92	.04	.81	-.20	.19
Other	.12	.43	.24	.11	.23	.13
Total	.08	.61	-.01	.92	.05	.77

Note. Sex coded as boy (0), girl (1), as such positive correlations represent higher frequency of utterance associated with increased likelihood of child being female.

Was mental state talk associated with greater social competency? As I found a female advantage for exposure to, and use of, mental state talk, I also explored whether these factors may be associated with greater social competency. Specifically, I

explored the associations between those mental state utterances where a sex difference was evident, and the teacher and parent ratings of social competency. I used partial correlations (controlling for age). Results are presented in Table 3.13. There was no evidence of any association between parent use of mental state talk and social competency. However, positive correlations were evident for the associations between children's overall use of mental state talk, and parent ratings of social competency, as well as teacher ratings of popularity. That is, the child's more frequent use of mental state talk, when engaged in play with a parent, was associated with higher parent ratings of overall social competency, as well as use of play time. Further, more frequent use of mental state talk by the child was also associated with higher ratings of popularity (number of friends).

Table 3.13

Results of Partial Correlations, Controlling for Age, Between Mental State Talk by Parent or Child and Social Competency

	r				
	Parent			Child	
	Cognitive	Assertion	Overall	Desire	Overall
Parent					
Overall	-.25	-.11	-.08	.29	.43*
Play	-.28	-.08	-.11	.33	.46*
Adaption	-.25	.14	-.06	.22	.22
Relating	-.29	-.34	-.17	.18	.16
Teacher					
Overall	.01	-.16	-.13	.05	.27
Dominance	.12	-.02	-.03	.20	.19
Aggression	-.11	.06	-.14	.19	-.08
Emotions	.04	.04	-.02	.06	.22
Prosocial	.13	.07	-.002	-.21	.03
Popularity	.05	-.08	-.07	.08	.37*
Friendships	.08	-.16	-.13	.05	.22

* $p < .05$

Mental state talk and pretend play. While mental state talk was largely not associated with social competence, I remained interested in whether it may be associated with pretend play, given both mental state talk and pretend play are environments said to encourage more complex social interactions. As such, I was

interested in whether increased use of, or exposure to, mental state talk would predict play preference. Logistic regressions, controlling for age, were again used. Overall parent use of mental state talk failed to significantly predict play preference, *Wald*(1) = 1.81, $p = .18$, *Exp*(*B*) = 0.95, 95% CI [0.88, 1.02]. However, children's overall use of mental state talk did significantly predict play preference, *Wald*(1) = 5.99, $p = .01$, *Exp*(*B*) = 0.74, 95% CI [0.57, 0.94]. In sum, while parent use of mental state talk failed to predict play preference, children who used more mental state utterances were more likely to show a preference for role play pretend play games in the pre-school environment.

Results Summary

The purpose of this study was to explore whether sex differences in typical development, and particularly theory of mind, may explain why ASD is diagnosed less in girls than boys. It was predicted girls would present with a female advantage in theory of mind (potentially due to an advantage in mental state talk or executive function) and consequently typically-developing girls would present with more advanced social competence. However, I found little evidence to support this hypothesis. Two theory of mind tasks (out of six) showed a female advantage. However, these skills were not significantly associated with measures of social functioning (with the exception of an association between Knowledge Access and teacher rated aggression). I did find some evidence of a female advantage in mental state talk. That is, parents of girls, and the girls themselves, used significantly more mental state utterances compared to boys. I proposed this may indirectly mediate the association between sex and theory of mind, but this was not the case. However, I did find that children who used more mental state utterances showed a stronger preference for pretend play (also preferred by girls). As such, girls seemed to be more frequently

exposed to environments that promoted more complex socialising. This included exposure to language that encouraged perspective taking, and a preference for games that involve more complex interactions (compared to games such as physical play).

Discussion

The overarching aim of this study was to explore whether a female advantage in cognitive and social abilities may provide some insight into why girls develop ASD less frequently than boys. That is, I explored whether typical sex differences, namely a female advantage, in cognitive and environmental constructs associated with social development, may explain why girls are less likely to meet criteria for ASD than boys. I was particularly interested in exploring sex differences in typically-developing theory of mind, along with factors associated with its development, namely, executive function and mental state talk. Theory of mind, and associated skills, were of most interest due to their association with social functioning. Consequently, I predicted that a pre-school female advantage in theory of mind, and associated skills, would be associated with an advantage in the social competence. In turn, I theorised that this advantage may mean girls are less likely to develop ASD (where social functioning is a key impairment; American Psychiatric Association, 2013).

Contrary to predictions I found no evidence of girls having a general advantage in their overall theory of mind ability (as evidenced by overall performance on the theory of mind scale). However, when I explored performance on the individual tasks I did find a female advantage on two of the six tasks. From the theory of mind scale I found girls were more likely to pass the Knowledge Access task (task 3 out of 5), while there was also evidence of girls performing better on the additional Sally-Anne false-belief task. Knowledge Access is the ability said to precede false-belief development (Peterson et al., 2005; Wellman & Liu, 2004). More specifically, Knowledge Access is

the ability to judge another's knowledge of an environment. While performance on the task requires the ability to interpret a person's knowledge, it does not require the child to guess what that person would specifically belief to be in the box (e.g., Band-aids). False-belief is the ability to judge that another's knowledge of the location of an object may be false based on the person's previous experience, and further, judge how this will influence the person's decision-making.

The female advantage on the Knowledge Access task but not on the remaining four scaled tasks, may capture the task most developmentally sensitive to the age of the sample (2-5 year olds). That is, as the children were all considered typically developing, we may have seen a ceiling effect on earlier tasks (Diverse Desires and Diverse Beliefs; where majority of children passed) and floor effect on later tasks (False Belief and Hidden Emotion, where few children passed). However, descriptive statistics (presented in Chapter 2) suggest there was still some variance in performance on other tasks. In particular, 57% of children passed the earlier Diverse Desires task (Task 2). While it is outside the scope of this thesis to explore this further, it would be useful for research to use the five-item theory of mind scale to longitudinally explore development of the five abilities starting from the toddler years. A longitudinal study could investigate whether young girls potentially develop each theory of mind ability slightly earlier than boys.

Sex differences on two theory of mind tasks may have captured those tasks sensitive to the developmental period captured by the sample. Alternatively, results may indicate a slight female advantage in false-belief related abilities. Regardless, conclusions drawn on the impact this may have had on the diagnostic rates of ASD are dampened by the lack of associations between these abilities and social competency. If theory of mind abilities were indeed protecting young females from meeting ASD criteria, as frequently as boys, I would expect advantages to be associated with

advanced social competence. However, I found little evidence that any of the six theory of mind tasks were associated with ratings of social functioning based on both teacher and parent report. The only exception to this was Knowledge Access performance, which indirectly mediating an association between being a girl and having better teacher-rated prosocial skills and lower aggression.

These findings are in contrast to previous studies showing more robust links between theory of mind and social development (C. Hughes & Leekam, 2004; Watson, et al., 1999). The distinct lack of association between theory of mind and social skills in this study may be due to this study's focus on a younger age range. The majority of theory of mind studies pertain to children over 3 years of age, with average ages usually over five years of age (e.g., Watson, et al., 1999). Potentially in a younger age range, a dynamic time for social development, the advantages of having better theory of mind are yet to emerge. However, it is also possible that the scale's tasks do not provide a sensitive enough measure of theory of mind, to find associations with social competence. The scale has thus far been used to assess theory of mind development across the five tasks, however, this was the first study to explore how the tasks were associated with social competence. Consequently, it will be important for future research to determine if and how these tasks may be associated with social competence. However, this explanation would not explain the lack of association between performance on the Sally-Anne false belief task and social competence, given false belief ability has been associated with social competence in slightly older samples (e.g., Caputi, et al., 2012; Happé & Frith, 1996). I also acknowledge some limitations to this study that may have hindered the ability to draw comparisons between theory of mind and social functioning. That is, the small sample (particularly for parent social ratings on the VABS-II) and the use of an unstandardized measure of teacher ratings of social

functioning may have impeded the ability to find links between theory of mind and social skills. Nevertheless, again, the longitudinal use of this scale to explore how theory of mind impacts social functioning across the toddler to early school years would be an interesting area for future exploration.

Where evidence was most robust, regarding potential reasons for the diagnostic difference, was in environments children were exposed to that encourage social development. Foremost, I found evidence that girls were both exposed to, and used, more mental state talk when interacting with their parents. Both girls, and parents of girls, used more mental state utterances overall, meaning their interactions involved more references to the idea that others may have different perspectives from their own. Girls were also found to use more utterances pertaining to desires (e.g., 'like', 'want') while parents of girls engaged in more frequent use of cognitive utterances (e.g., 'think', 'know') and assertion utterances ('maybe', 'might'). Interestingly, desire utterances have been shown to precede the development of cognitive, and then assertion utterances, during the pre-school years (Taumoepeau & Ruffman, 2008). This provides insight into two potential explanations for the sex difference in mental state talk. First, it may be that girls are more advanced in their mental state talk, leading parents to match, and then extend on this language. Alternatively, parents of girls may be aiding their daughter's more advanced mental state talk by exposing them to more complex utterances at a younger age. Taumoepeau and Ruffman (2008), in their longitudinal analysis of mental state talk development in the early toddler years, found the latter to be true. That is, parents' early use of more complex mental state talk predicted children's later use of mental state talk.

Girls' more frequent use of mental state talk was also associated with a stronger preference for conversational pretend play. This style of play was of particular interest

to this study given its ability to provide a practice ground for children to learn many skills and rules of social development (including perspective taking; Lillard, 1993). Girls showed a far stronger preference for this style of play, while boys' preferences were more evenly spread between physical (rough and tumble) play and pretend play. As such, typically-developing girls were exposed to more complex social environments both in the home- (through mental state talk) and pre-school-setting (through play preference). These environments may provide girls with a rich practice ground for learning and practicing social rules. However, I failed to find robust evidence that these environmental advantages were associated with girls' greater theory of mind or social competence. This may have been due to the nature of the sample. In particular, all children were typically developing; meaning, regardless of play preference or mental state use, all children had typically developing social skills. If this pattern of results were to persists in longitudinal studies, it seems unlikely this would protect girls from developing ASD (especially in conjunction with evidence of little sex differences in executive function, theory of mind, and social skill). However, it is possible that developmentally 'at-risk' girls may also be provided with this richer practice ground (i.e., pretend play and mental state utterances). In turn, this may allow them to better learn social etiquettes and rules, potentially making social impairments less salient.

Summary and Future Direction

The results of this study provided many potential areas for the future direction of this thesis. I found some evidence of a female advantage in knowledge access and false-belief theory of mind abilities. However, there was little evidence of robust associations between these abilities and social functioning. Further, there was no evidence of sex differences in executive function abilities. As such, I found little evidence of a female advantage in theory of mind or executive function. However, I do

not rule out that other cognitive abilities or protective mechanisms, related to social development, and not assessed in this thesis, may play a role in protecting girls from developing ASD as frequently as boys. Moreover, it remains to be tested whether there is a female advantage in such cognitive and social abilities in samples of children both with ASD, and in the sub-clinical range. Exploring sex differences in processes such as theory of mind and executive function, in samples of children with ASD, may provide important information regarding why ASD may develop less, or present differently, in girls.

I did find evidence that girls are exposed to environments that promote the practice and exposure to more complex social rules (namely mental state talk and pretend play). For those cognitively-able girls with ASD, where no intellectual impairment is evident, I propose this may enable girls to better learn social etiquette. That is, perhaps cognitively-able girls with ASD are also exposed to these social environments, and as a result, are able to learn social etiquette that may then hide their true impairments. While it is not within the scope of this thesis to further explore mental state talk, in the remaining chapters I was interested in exploring whether sex differences in play preference may also be evident in samples of children with ASD. The idea that girls may be better able to hide underlying impairments will be the focus of the remainder of this thesis.

Chapter 4: Study 2

Sex Differences in Pre-Diagnosis Concerns for Children Later Diagnosed With ASD[11]

In the previous chapter I explored whether girls may be protected from developing ASD as readily as boys, due to an advantage in typical social and cognitive abilities. However, little evidence was found to support this theory. Consequently, for the remainder of this thesis I explore the second theory, that the sex difference in the diagnostic rates reflects the under-detection of girls. In the absence of intellectual impairment, girls are not only diagnosed 4-10 times less than boys but are also diagnosed significantly later (Begeer, et al., 2012; Fombonne, 2009; Siklos & Kerns, 2007). Evidence of the later diagnosis of cognitively-able girls with ASD, is despite there being no difference in the number of visits to a health care professional during the diagnostic process (Siklos & Kerns, 2007) and no difference in the age at which parents first express concern (Begeer, et al., 2012). These findings suggest diagnosing the disorder in girls in the younger years is especially problematic, meaning many would miss the of the potentially important early intervention, or, at the very least, early support for the child and family. Further, it suggests that, while certain biological factors may protect girls from developing ASD as readily as boys (Baron-Cohen, 2002; Werling & Geschwind, 2013), the current magnitude of the sex discrepancy is also potentially due to the under-identification of the disorder in cognitively-able girls. Consequently, the difficulty diagnosing the disorder in girls may be due to the clinician or other professional's difficulty identifying signs of ASD in girls, or difficulty with the current assessments used for ASD in identifying these early signs. My study expanded

[11] A large proportion of this chapter is currently under review. Hiller, R. M., Young, R., Weber, N. Sex differences in the pre-diagnosis concerns for children later diagnosed with autism spectrum disorder.

on current knowledge of the detection of ASD in cognitively-able females using parent report on the pre-school years. To explore why the disorder may be more difficult to identify early in girls, I focussed on those children who, despite early concerns, were not diagnosed until school age, meaning parents were reporting on the pre-diagnosis concerns they held for their child.

Regardless of sex, late diagnosis of ASD is often associated with higher cognitive ability (Rivet & Matson, 2011). It has been hypothesised ASD is more difficult to detect in cognitively able children because the early signs and symptoms of ASD present as less severe. Alternatively, or possibly additionally, a cognitively able child with ASD may be able to form compensatory strategies to camouflage early impairments. What we do not yet know is if early signs or compensatory strategies may differ for boys and girls. To fill this gap in the literature, this study had two aims. First, I explored sex differences in early symptoms (e.g., restricted interests, social reciprocity) and associated signs (e.g., imitation) of ASD. Second, I investigated sex differences in the strategies pre-school aged boys and girls reportedly used to navigate their social environment. To gain insight into why it may be harder to early detect ASD in girls I was particularly interested in exploring sex differences in a population of children who, despite concerns for development in the toddler years, were not diagnosed until their school years.

The camouflage hypothesis (Attwood, et al., 2006; Kopp & Gillberg, 1992) is one hypothesis used to explain the sex difference in the diagnostic rates of community samples of children with ASD. The theory makes hypotheses about sex differences in both differing symptoms presentation and compensatory strategies, to explain why ASD is more difficult to identify in girls. The theory posits that girls are better at watching and copying others' socialising, resulting in an apparent reduced impairment in 'classic'

ASD early signs, such as impaired use of social gestures and difficulty initiating social contact (Attwood et al., 2006; Kopp & Gillberg, 1992). At the centre of this theory is girls' hypothesised superior imitation abilities, which affects both their behaviour presentation and the social strategies used. Moreover, away from the social domain, the theory suggests girls present with differing types of obsessions that are not seen as 'classic' restricted interests commonly associated with ASD (or more specifically boys with ASD; Attwood et al., 2006; Kopp & Gillberg, 1992). There are numerous reasons, as yet untested, as to if or why there may be sex differences in the restricted interests of boys and girls with ASD. Perhaps girls' interests appear more 'gender-typical' in the early years or do not fit the stereotyped idea of 'classic autism' (e.g., the boy lining up cars and refusing to play with cars in a pretend-play format). Potential reasons for any difference may include a biological propensity for boys and girls to play with different toys, or simply because of the toys made available to boys and girls. Regardless, there is currently no evidence of whether there is indeed a sex difference in the restricted interests of boys and girls with ASD. Consequently, through this study I was interested in exploring whether there would be evidence of a sex difference in the early restricted interests of boys and girls who would go on to meet criteria for ASD.

Importantly, the theory also suggests overt behaviour differences are present, despite significant underlying social impairments. For example, girls may appear to present with less impaired social behaviours but actually fail to understand many rules of socialising, as one would expect of an individual with ASD (Kopp & Gillberg, 1992). Attwood and colleagues (2006) suggest girls may somehow be able to camouflage their underlying lack of social understanding, however how and why this may be remains an area of important investigation. A key aim of my study was to provide an empirical investigation of both whether boys and girls do indeed engage in different social

compensatory strategies, and whether a female advantage in key signs of ASD may influence the difficulty identifying the disorder in girls.

A recent study by Kothari and colleagues (2013) provided some support for this hypothesis. They found that girls considered to have high autistic traits were better than their male counterparts at facial emotion recognition. However, they were equally impaired in their ability to make correct novel social emotion recognition decisions. The authors suggested this could demonstrate girls high in autistic traits demonstrated intact recognition skills that are possible to learn (i.e., identifying what an emotion looks like) but were impaired at making accurate recognition decisions based on a novel social task, which could not be learnt. That is, girls performed better on a task that could be learnt, but were equally impaired in their underlying social understanding. While this provides some insight in to possible support for the camouflage hypothesis, the study engaged a general population and thus did not determine whether the children had, or would go on to have, a diagnosis of ASD.

The first potential explanation I explored in this study, for the sex difference in the rate and timing of ASD diagnoses, was different symptom presentation. Studies on sex differences in the core symptoms of individual's with ASD have produced inconsistent results. When controlling for IQ, one of the more consistent findings has been evidence that fewer girls than boys present with restricted interests across toddlerhood, childhood, and adolescence (Carter et al., 2007; Hartley & Sikora, 2009; Lord, et al., 1982; Mandy, et al., 2012; Szatmari, et al., 2012). However, Attwood and colleagues (2006) have proposed that girls present with different types of restricted interests to boys that may be more difficult to identify as atypical. Consequently, current evidence of girls presenting with fewer restricted interests may be partially due to the under-detection of how these interests manifest in girls. Thus, a key contribution of this

study is the first empirical examination of sex differences in the types of restricted interests displayed by pre-school aged boys and girls who go on to receive a diagnosis of ASD.

On the social domain, there is evidence of no significant sex differences in the social communication abilities of pre-schoolers (Andersson, et al., 2013) and children with ASD, including a recent study that used a larger sample of cognitively able girls all diagnosed with ASD (Mandy, et al., 2012). However, again, the literature has also shown evidence of females having both more severe (Hartley & Sikora, 2009; McLennan, et al., 1993) and less severe social deficits (Lai, et al., 2011; Zwaigenbaum et al., 2012). Consequently, the current literature provides no clear consensus on the role of the social domain in explaining why ASD may be more difficult to detect in girls. Further, few studies have explored the role of sex differences in the broader ASD phenotype. While these broader features (e.g., imitation) are not found in the DSM criteria, they do potentially lend to the 'look' or behavioural presentation of the child. Hence, these features may influence whether a medical professional explores whether developmental concerns may be a sign of ASD (compared to any other developmental disorder). Consequently, if these features present differently in girls compared to boys, it may further account for the difficult identifying the disorder in girls.

A second area of interest to this study was investigating sex differences in strategies used by pre-school children to navigate their social environment. There is a stark paucity of research in this area. The literature provides no information on social compensatory strategies used by children, prior to when they received a diagnosis of ASD. Although Kopp and Gillberg (1992) presented case studies of girls engaging in imitation to hide social impairment, there is no empirical evidence for the strategies used by boys and girls with ASD to navigate their pre-school social environment.

Further, while there is some evidence of strategies and skills developed by children following targeted social intervention, this information fails to provide insight into whether girls may be spontaneously engaging in strategies that make the disorder more difficult to detect in the first place (McConnell, 2002; Rao, Beidel, & Murray, 2008).

In sum, there is currently little evidence on why such a large sex difference exists in the diagnostic rates of ASD and in particular why it may be more difficult to early detect in girls. Research has primarily focussed on sex differences in core symptoms of ASD once a diagnosis has been given, meaning we do not understand why the diagnosis of ASD may be missed in girls during the pre-school years. Consequently, we know little about why ASD appears harder to detect early in girls. In this chapter, I have extended on the current literature by specifically examining sex differences in the pre-diagnosis concerns held by parents, for children who were late-diagnosed with high-functioning ASD. As such, I have explored a sample who could (or possible even should) have been diagnosed earlier, but were not. Through this I explored what specific concerns led a parent to seek advice on their child's development. Thus, patterns in this sample could provide insight into the relevance of the camouflage hypothesis as an explanation for the under-detection of ASD in girls (Attwood, et al., 2006). This exploration was three-fold. First, when pre-school aged, did girls present with different signs of ASD compared to boys? Most relevant was exploring whether there was, in fact, a sex difference in boys' and girls' ability to imitate. Second, I was interested in whether girls engaged in different social compensatory strategies to boys, and whether these strategies may make signs of ASD more difficult to identify. Finally, I have provided the first empirical investigation into the specific types of restricted interests commonly shown by girls versus boys, to again investigate whether girls' interests may be more difficult to detect as atypical, or a sign of ASD.

Method

Participants

Participants were recruited through State-wide Autism organisations in Australia (Autism Spectrum Australia, Autism Victoria, Autism SA, and Autism Western Australia) and two private practices, specialising in the diagnosis and treatment of individuals with ASD. The study was advertised through the websites and newsletters of the autism organisations and one of the private practices, and through flyers at the other private practice. One hundred and eighty seven people completed the online questionnaire. Of these, 171 (92%) identified themselves as the mother of the child, with the remaining identified as the father, grandmother, or foster-parent/carer. The majority of the children were from South Australia (30.4%), followed by Victoria (13.9%), and New South Wales (20.3%). Twenty five percent of participants provided no information on locality.

To participate in the survey, the child reported on was required (1) to have a current diagnosis of ASD (including Asperger's Disorder), (2) to have no intellectual disability, (3) to have been diagnosed from school age (> 5 years old), and (4) to be currently aged between 5 and 18 years of age. Using these criteria, 152 surveys were eligible for inclusion. Thirty-five were excluded for either not providing the current age of the child, the age the child was diagnosed, or the child's current diagnosis.

Of the 152 eligible surveys 60 were completed for a girl with ASD (39.5%) and 92 reported on a boy (60.5%). The higher percentage of girls recruited, than what is reflected in our knowledge of the sex ratio of autism, may have been due to the private practices targeted being widely regarded and specialising in the diagnosis of ASD in girls. Consequently, these practices likely see a higher proportion of girls with ASD than may be typically seen. The children ranged in age from 6 to 17 years old (M =

10.94 years, *SD* = 3.11). While there the average age of girls (*M* = 10.27 years, *SD* = 3.05) and boys (*M* = 11.27 years, *SD* = 2.99), $t(150) = 1.99$, $p = .05$, $d = .33$ did not significantly differ, the effect size suggests this may be a power issue. As such, current age was controlled for in all analyses.

Of note, due to the timing of data collection, participants would have been diagnosed based on DSM-IV-TR criteria. The largest percentage of boys and girls had been diagnosed with Asperger's Disorder (girls: 81.7%, *n* = 49; boys: 63.0%, *n* = 58). Autistic Disorder (or Autism Spectrum Disorder) was the diagnosis for 26.1% of boys (*n* = 24) and 11.7% of girls (*n* = 7). Ten boys (10.9%) and four girls (6.7%) had a diagnosis of Pervasive Developmental Disorder Not Otherwise Specified (PDD NOS).[12] Average age of diagnosis was 8.72 years (SD = 2.52). All except one child attended mainstream schooling (with five of those children spending time in a disability specific class, within the mainstream system). The one child who did not attend a mainstream school, attended a disability specific school. Refer to Table 4.1 for information on infant health, birth order, and age of walking.[13]

[12] There was no significant sex difference in the category of diagnosis, $\chi 2(2) = 6.19$, $p = .05$, $\phi_c = .20$. While diagnosis was made using DSM-IV-TR, in line with recommendations made in the new DSM-5, the umbrella term of Autism Spectrum Disorder (ASD) will be used throughout the paper (American Psychiatric Association, 2000; 2013).

[13] There was no evidence of a significant sex difference across these characteristics (Birth order: $\chi^2(4) = 4.11$, $p = .39$, $\phi_c = .17$; Health: $\chi^2(5) = 2.68$, $p = .75$, $\phi_c = .14$; Walk: $\chi^2(4) = 2.42$, $p = .66$, $\phi_c = .13$).

Table 4.1

Participant Characteristics for Birth Order, Health Problems, and Walking Age

				% (*n*)			
Birth Order	Only child	First born	Last born	Middle child	Foster child	Not reported	
	10.5 (16)	43.4 (66)	22.3 (34)	18.4 (28)	0.7 (1)	4.6 (7)	
Infant Health	Normal	Respiration Problems	Skin Allergies	Feeding Problems	Diarrhoea/ Constipation	Several Problems	Not reported
	36.2 (55)	4.6 (7)	8.5 (13)	10.5 (16)	5.9 (9)	28.9 (44)	5.3 (8)
Walking (month)	8-12	13-15	19-24	25-36	>36	Not reported	
	36.1 (55)	39.5 (60)	9.9 (15)	7.2 (11)	3.3 (5)	3.9 (6)	

Measure and Procedure

Respondents completed a 40 item online survey, with a combination of multiple-choice and free-response options. The full survey is presented in Appendix F. A questionnaire measure was used primarily to allow access to a larger sample of carers of girls with ASD, than what would have been possible to capture in other methods, such as in-depth interviews. Questions fell into five categories: (1) general milestones (e.g., walking), (2) general concerns (e.g., vocabulary, imitation, play), (3) responses from professionals (e.g., timing of concern expressed by a teacher, response from professionals when concerns expressed, other diagnosis queried), (4) social strategies (i.e., what strategies the child used to navigate social environments), and (5) repetitive/ritualistic behaviours. The majority of questions pertained to the child's functioning during the pre-school years (3-5 years of age). That is, parents were instructed "unless otherwise specified, the following questions refer to concerns you may have held for your child during the PRE-SCHOOL YEARS (i.e., before 5 years of age)." Where explicitly stated (e.g., "In the first year"), some questions referred to

infancy (e.g., infant health problems, milestones). The survey was based on items common to standardised diagnostic tools (e.g., imitation ability, ability to manage change), with the addition of items more specific to test whether there was evidence of sex differences in such factors as social compensatory social strategies and types of restricted interests.

Statistical Analysis

For the major analyses I used hierarchical logistic regressions, with sex (boys – 0, girls – 1) as the outcome variable. This analysis directly addresses the key research question: How strongly is a given predictor indicative of a child being a girl (or boy)? Consequently, these analyses provide more useful information than simply examining sex differences in proportions or means of predictor variables. As the average age of the girls in our sample was slightly (but not significantly) younger than the boys, we controlled for age in all analyses. That said, regardless of current age of the child all participants were reporting on the child's development during the pre-school years, prior to when a diagnosis was received. I used logistic regression equations to calculate the predicted odds for each level of all significant predictors. Odds ratios are asymmetrical around 1, meaning it is difficult to compare odds ratios favouring girls (>1) with those favouring boys (<1). Consequently, I transformed all odds ratios to >1 and have noted whether the ratio favours girls or boys. All predicted odds ratios have also taken into account the higher proportion of boys in our sample. Consequently, a larger odds ratio is indicative of a stronger association between sex and the predictor variable. A final issue to consider when interpreting the logistic regression results was the imbalanced sex ratio in our sample (92 boys versus 60 girls). As a consequence of this, the predicted odds ratios from the logistic regressions reflect this imbalance. However, this makes interpretation difficult. So, I applied Bayes' theorem to correct the

predicted odds ratios. Specifically, ratios predictive of being a boy were multiplied by 0.65 (number of girls/number of boys; 60/92) while ratios predictive of being a girl were multiplied by 1.53 (number of boys/number of girls). Consequently, results represent the predicted odds of being either a boy or girl, based on there being an even proportion of each sex. To gain a snapshot of ASD severity, respondents also rated the child's level of functioning based on the proposed severity rating scales of the DSM-5 (American Psychiatric Association, 2013). This scale assesses the level of support the child required on both the social/communication domain and the repetitive/ritualistic domain (ranging from mild - 'Requiring Support', to moderate - 'Requiring Substantial Support', to significant - 'Requiring Very Substantial Support').

Results

Descriptive Statistics

Severity rating. Respondents first rated the child's level of functioning based on the proposed severity rating scales used in the fifth edition of the Diagnostic and Statistical Manual[14] (DSM-5; American Psychiatric Association, 2013). The level of support required on either domain did not significantly differ by sex (social: $\chi^2(2) = .10$, $p = .95$, $\phi_c = .03$; ritualistic: $\chi^2(2) = 1.91$, $p = .39$, $\phi_c = .11$). On the social domain, the majority of children only required minimal support ($n = 109$, 79.0%), 22 (15.9%) required moderate support and 5 (3.6%) required significant support (very substantial). Again, on the ritualistic domain, the majority of children required only minimal support ($n = 86$, 62.3%), 41 (29.7%) required moderate support and 9 (6.5%) required significant support.

Age and timing of concerns and diagnosis. There was no significant difference between the age of first concern for girls ($M = 38.10$, $SD = 29.89$ months)

[14] These scales remained in the final edition of the DSM-5 (American Psychiatric Association, 2013).

compared to boys (M = 40.14, SD = 25.63 months), $t(123) = .40$, $p = .68$, $d = .07$. Regardless of sex, concern with development first became apparent, on average, around 3 years of age. There was also no significant difference in the age of diagnosis of girls (M = 9.24 years, SD = 3.00) compared to boys (M = 8.45 years, SD = 2.26), $t(96.12) = -1.56$, $p = .12$, $d = .26$. Finally, while girls waited, on average, almost a year longer to receive a diagnosis (from first concern, M = 6.07 years, SD = 2.67) compared to boys (M = 5.21 years, SD = 2.67), this was not a statistically significant difference, $t(123) = -1.60$, $p = .11$, $d = .29$. On average, from age of first concern, it took girls six years to receive a diagnosis of ASD, while it took boys, on average, just over 5 years.

Initial General Concern and Initial Concern Specific to Social Development

Participants reported on the first concern held for the child's general and social development. Response options for first general concern were (i) language, (ii) social, (iii) routine dependence, (iv) motor skills, (v) behaviour, and (vi) medical issues. Overall, the first concern for development did not significantly predict sex, $Wald(5) = 8.61$, $p = .13$. Regardless of sex, first becoming concerned with the disruptive behaviour of the child was a common concern (girls: 39.7%; boys: 21.6%). For girls, besides behaviour concerns, reporting was distributed evenly across the other concerns (language: 12.1%; social: 10.3%; routine: 13.8%; motor: 13.8%; medical: 10.3%). For boys, 21.6% of participants reported first being concerned with medical issues, while 20.5% were first concerned with language development. Parents of boys also reported first concerns with social development (10.2%), routine dependence (10.2%), and motor skills (15.9%).

Free-report responses on the first concern held for the child's social development were coded as either (0) concern with externalising social behaviour (e.g., hitting, yelling, controlling play) or (1) concern with internalising/withdrawal (e.g.,

avoidance, remaining passive). Free-report responses were provided by carers of 63 boys and 46 girls. As participants provided free-report responses, twenty-five per cent of responses were coded by an independent rater, resulting in adequate interrater reliability with Cohen's kappa of $\kappa = .78$. I used logistic regressions to explore whether social concern (externalising v internalising) would predict sex (0 – boy, 1 – girl). Results are presented in Table 4.2. Results showed that, compared to those children for whom internalising social behaviours were of primary concern, reporting the primary concern as externalising behaviour was predictive of being female. Indeed, if externalising behaviour was reported as the key social concern, predicted odds ratio showed the child was over 3 times more likely to be a girl than a boy, with half of girls and only a quarter of boys having externalising behaviour as their primary social concern.

Sex Differences in Pre-Diagnosis Concerns

As the analysis of pre-diagnosis concerns was exploratory, a backward stepwise logistic regression was used to determine the group of early concerns that best predicted sex.[15] Results are presented in Table 4.2. All survey items pertaining to early signs of ASD (excluding free-reported social compensatory strategies, and types of restricted interests, which are discussed later) were recoded into dichotomous variables, as either normal/ no concern (0) or concern (1). The only exception to this was imitation, which was coded as complex imitation (0) or simple imitation (1). This was done because I was not only interested in whether the girls versus boys could imitate or not, but also whether this imitation ability may be developed enough to be used in social settings. Seventeen items were added in step 1 of the backward logistic regression. The analysis revealed 5 items that best predicted sex, $\chi^2(6) = 22.50$, $p = .001$ (see Table 4.2, which

[15] Multicollinearity was assessed and it was found that no items correlated above $r = .32$.

includes a footnote on excluded items). The items to best fit a model predicting sex were: (i) imitation complexity ('Before the age of 3, was your child able to imitate another person?'), (ii) withdrawn ('Would you describe your child around age 3-4years as often seeming withdrawn or distant?'), (iii) interest in parts of mechanical objects ('From 3-5 years of age was your child unusually interested in mechanical objects such as the stove or vacuum?'), (iv) desire to be liked ('During the pre-school years did your child seem to want to be liked by other children?'), and (v) vocabulary ('How would you judge your child's vocabulary below the age of 5 years?').

These items, using their original response format[16], were then added as single logistic regressions, with age controlled in Step 1 of all regressions. Table 4.2 shows results of logistic regressions, with descriptive statistics presented in Table 4.3. Based on these individual analyses the only lone item to not significantly predict sex was 'presenting as withdrawn or distant' ($Wald(2) = 1.93$, $p = .38$). All other variables remained predictive of sex. Almost 70% ($n = 36$) of girls were reportedly able to engage in complex imitation (i.e., imitation games or multiple actions), compared to 34% ($n = 30$) of boys. Almost a quarter of girls reportedly had an unusually strong desire to be liked ($n = 13$, 22%) compared to only 10% of boys ($n = 9$). Further, the majority of girls were rated as having either little or no interest in parts of mechanical objects ($n = 28$, 48%), while boys were most commonly rated as fascinated ($n = 49$, 55%). Finally, boys were reported as more likely to present with below average vocabulary ($n = 37$, 42%) compared to girls ($n = 16$, 28%). Indeed, the largest percentage of girls were rated as

[16] The only exception to this was the response options for 'vocabulary' which were collapsed from six possible responses to three (below average, average, above average) due to low reporting in other response options.

having above average vocabulary in the pre-school years (n = 26, 45%). Complete descriptive statistics are presented in Table 4.3.[17]

[17] Although there was no significant sex difference in the percentage of boys and girls diagnosed with Asperger's Disorder, Autistic Disorder, or PDD NOS, approximately 20% more girls were reported to have a current diagnosis of Asperger's Disorder. Under DSM-IV-TR, a diagnosis of Asperger's Disorder meant language impairment was not present (American Psychiatric Association, 2000). Consequently, for the purpose of clarity, I also explored whether each of these variables would still predict sex after controlling for diagnosis and age (rather than age alone). Unsurprisingly, the only variable affected was vocabulary, which no longer significantly predicted sex after controlling for diagnosis. Specifically, after controlling for diagnosis having below average vocabulary no longer significantly predicted being a boy, p = .34, *ExpB* = 0.64, 95% CI [0.26, 1.59].

Table 4.2

Results from Logistic Regressions on Individual Items that Significantly Predicted Sex After Controlling for Age

Item	Predicted Odds	*Wald*(df)	*p*	Exp*B* [95% CI]
First Social Concern				
Internalising*	1.86	6.02(1)	.01	0.35 [0.15; .81]
Externalising* (constant)	3.47	5.12(1)	.02	6.54 [1.28; 3.51]
Imitation		14.09(4)	.01	-
Simple imitation	1.13	0.01(1)	.91	1.09 [0.26; 4.48]
Imitation game*	5.12	5.51(1)	.02	4.92 [1.30; 18.57]
Complex * imitation	5.84	7.04(1)	.01	5.62 [1.57; 20.10]
Not sure	2.76	1.99(1)	.16	2.65 [0.69; 10.25]
No imitation (constant)	1.08	0.21(1)	.65	0.68 [0.13; 3.65]
Mechanical		19.04(2)	<.001	-
No interest*	3.33	18.60(1)	<.001	7.04 [2.90; 17.11]
Average interest	1.18	1.72(1)	.19	1.78 [0.75; 4.23]
Fascinated (constant)	2.10	0.72(1)	.96	0.97 [0.23; 3.94]
Desire to be liked		5.73(3)	.13	-
Unusually strong*	6.50	4.62(1)	.03	3.27 [1.11; 9.96]
Average	1.20	.002(1)	.97	0.98 [0.34; 2.82]

Indifferent	3.24	1.27(1)	.26	1.63 [0.70; 3.84]
Preference for solitary (constant)	1.19	0.13(1)	.72	1.30 [0.31; 5.42]
Vocabulary		4.39(2)	.11	
Below average*	1.02	4.34(1)	.04	0.42 [0.19; 0.95]
Average	3.47	1.32(1)	.25	0.61 [0.26; 0.95]
Above average (constant)	5.69	2.91(1)	.09	3.72 [0.84; 12.94]

Note. Removed variables: response to light; response to being held; health; imitation; withdrawn presentation; lining up objects; destructive; managing change; aggression; providing comfort; friends; preparation to be picked up; play style. Underlined predicted odds ratios represent variables that predicted being a girl. CI = confidence interval.

* $p < .05$

Table 4.3

Descriptive Statistics for Parent Report on Pre-Diagnosis Concerns That Significantly Predicted Sex of the Child

Item	Girls *n* (%)	Boys *n* (%)
First Social Concern		
Internalising*	25 (54.3)	48 (76.2)
Externalising*	21 (45.7)	15 (16.3)
Imitation		
Simple	6 (10.7)	24 (27.0)
Imitation game*	15 (26.8)	13 (14.6)
Complex*	21 (37.5)	17 (19.1)
Not sure	10 (17.9)	18 (20.2)
No imitation	4 (7.1)	17 (19.1)
Mechanical		
No interest*	28 (48.3)	13 (14.6)
Average interest	15 (25.9)	27 (30.3)
Fascinated	15 (25.9)	49 (55.1)
Desire to be liked		
Unusually strong*	13 (22.4)	9 (10.1)
Average	8 (13.8)	19 (21.3)
Indifferent	24 (41.4)	31 (34.8)
Solitary	13 (22.4)	30 (33.7)
Vocabulary		
Below average*	16 (27.6)	37 (41.6)

Average	16 (27.6)	26 (29.2)
Above average	26 (43.3)	26 (29.2)

* $p < .05$ based on logistic regression results

Of note, impairment in the remaining items (listed under Table 4.2) all failed to predict sex. This included such abilities as providing comfort or noticing when another person was upset. For over 85% of boys and girls in the sample, respondents noted that this ability to notice and respond appropriately to another person being upset was impaired. For half of boys and girls, respondents reported the child did not seem to even notice if another person was upset, while approximately 20% were reportedly highly sensitive to others being upset, yet did not appear to know how to appropriately respond. Similarly, approximately half of the boys and girls in the sample were rated as seemingly unable to identify emotions during the early pre-school years. Consequently, while there were some key sex differences in early developmental concerns, there were also many similarities in the reporting of early concerns for boys and girls with ASD.

Sex Differences in Type of Restricted/Repetitive Behaviours (RRB)

I was also interested in exploring the type of restricted interest of most concern to caregivers during the pre-diagnosis stage. Based on the camouflage hypothesis (Attwood et al., 2006) I predicted that girls and boys would reportedly present with different restricted interests, with girls interests potentially more difficult to identify as atypical. Caregivers free-reported on the most concerning type of obsessions/restricted interest held by the child during the preschool years. Responses were provided by 66 carers of boys and 39 carers of girls. These responses were coded in to one of five categories, based on the emergent concepts from caregiver report. These were, obsessive interests in (i) wheeled vehicles (e.g., lining up of cars, collecting of trucks),

(ii) toys (e.g., collecting teddy bears, lining up barbie dolls), (iii) random objects (e.g., collecting glitter, shells, erasers), (iv) screens (e.g., computers, television), and (v) characters (i.e., a particular television or movie character). Using these themes, interrater agreement was completed on 25% of the sample by an independent rater, blind to research aims, with Cohen's kappa of $\kappa = .79$. Table 4.4 shows logistic regressions results for what specific types of interests predicted sex. Of note is that fascination with wheeled toys (cars, trucks) or parts of those toys was strongly predictive of being a boy. Over half of the boys in the sample (59.1%, $n = 39$) compared to only two girls (5.1%) were reported to show atypical fascination with wheeled toys. Thirteen girls (33.3%) and only four boys (6.1%) demonstrated fixation on seemingly random objects (e.g., erasers, glitter, shells), while 15 girls (38.5%) and 9 boys (13.6%) demonstrated fixation with toys (e.g., teddy bears, Barbie dolls).

Table 4.4

Logistic Regression Results for Type of Restricted Interest of Most Concern During Pre-School Years

Strategy	Predicted Odds	*Wald*(1)	*p*	Exp*B* [95% CI]
Wheeled-toys	13.54	5.14	.02	0.12 [0.02; 0.76]
Toys	<u>2.87</u>	4.37	.04	4.69 [1.10; 19.97]
Seemingly random	<u>1.82</u>	5.67	.02	2.98 [1.41; 33.40]
Screens	<u>1.82</u>	1.33	.25	2.98 [0.46; 19.17]
Character (constant)	1.63	0.52	.11	0.40 [0.06; 1.25]

Note. Underlined predicted odds ratios represent variables that predicted being a girl.

Strategies Used for Navigating Social Situations

Another aim of the study was to investigate sex differences in strategies used to manage pre-school social environments. I explored whether girls did indeed engage in different social compensatory strategies to boys. Respondents provided free-report responses on whether the child used a consistent strategy to navigate social situations in the pre-school years. Responses were coded into five categories: (i) no consistent strategy, (ii) mimicking, (iii) maintaining a close friend, (iv) isolating/withdrawing, and (v) talking to adults. Interrater agreement was completed on 25% of the sample by an independent rater, with a Cohen's kappa of $\kappa = .89$ demonstrating adequate interrater reliability. After controlling for current age, social compensatory strategies significantly predicted sex, $Wald(4) = 15.49$, $p = .004$. As shown in Table 4.5, if a preference for mimicking as a social strategy was reported, the child was over 16 times more likely to be a girl. Indeed, 37% of the girls ($n = 20$) reportedly engaged in mimicking (i.e., copying/social scripts) as their primary strategy for managing social situations (compared to 10% of boys, $n = 8$). The second most common strategy for girls (24%, $n = 13$) was talking with adults or teachers, with 29% of boys ($n = 24$) also engaged in this strategy most frequently. The only strategy to predict being a boy was isolating from play (i.e., leaving or remaining a passive observer). This was the primary social strategy for 29% of boys ($n = 24$) compared to 17% of girls ($n = 9$). As such, supporting predictions, engaging in mimicking behaviour to manage social settings was a more common strategy for girls than boys.

Table 4.5

Results of Logistic Regression of Compensatory Social Strategies Used to Navigate Social Situations

Strategy	Predicted Odds	*Wald*(*df*)	*p*	Exp*B* [95% CI]
Mimicking	16.43	5.76(1)	.02	4.65 [1.31; 16.34]
Close friend	4.21	0.08(1)	.79	1.19 [1.33; 4.26]
Isolating	1.66	1.75(1)	.19	0.40 [0.10; 1.56]
Talking to adults	3.28	0.01(1)	.91	0.93 [0.29; 2.98]
No consistent strategy (constant)	5.53	0.94(1)	.33	2.31 [0.42; 12.81]

Note. Underlined predicted odds ratios represent variables predictive of being a girl.

Initial Concerns of Teachers and General Practitioner

Caregivers also reported on the responses they received from teachers and medical professionals regarding concern for the child's development. For teacher response, participants reported on the age of their child when a teacher first expressed concern. This was then coded into one of five categories: (i) no concern, (ii) concern expressed before 42 months of age, (iii) concern expressed between 43 and 60 months of age (kindergarten), (iv) concern expressed between 61 and 72 months of age (first year of school), (v) concern expressed after 72 months of age (school aged). Again, I used logistic regressions, controlling for age (see Table 4.6 for logistic regression results and Table 4.7 for descriptive statistics). Reported timing of concern expressed by teachers did predict sex, $Wald(4) = 9.51$, $p = .05$. If the participants reported that no teacher had ever expressed concern for the child's development, the child was over 13 times more likely to be a girl. For 25% of girls ($n = 15$) no teacher had ever reported

concern to the parent, compared to 7.1% (n = 6) of boys. Consequently, at least from the caregivers' perspective, teachers were far less likely to express concern with a girls' development or behaviour at any point in their schooling.

Table 4.6

Logistic Regression Results for Timing of Teacher Concern Predicting Sex

Timing of Concern	Predicted Odds	*Wald*(*df*)	*p*	Exp*B* [95% CI]
Teacher concern (overall)		9.51 (4)	.05	-
No concern (constant)	13.65	6.59(1)	.01	8.93 [1.68; 47.46]
Childcare (<42mo)	1.34	5.17(1)	.02	0.24 [0.07; 0.82]
Pre-school (42-60mo)	1.01	8.61(1)	.003	0.18 [0.06; 0.57]
First year of school (61-72mo)	1.12	5.86(1)	.02	0.20 [0.05; 0.74]
Later primary (<72mo)	2.01	2.51(1)	.11	0.35 [0.09; 1.29]

Note. Underlined predicted odds ratios represent variables predictive of being a girl.

Table 4.7

Descriptive Statistics for Timing of When Teacher First Expressed Concern for Child

Timing	Girls *n* (%)	Boys *n* (%)
Childcare	11 (18.6)	17 (20.2)
Kindergarten	16 (27.1)	35 (41.7)
First year of school	8 (13.6)	15 (17.9)
School	9 (15.3)	11 (13.1)
Never	15 (25.4)	6 (7.1)

Response from family doctor and other diagnoses queried. For reported responses from medical professionals, participants reported in a multiple-choice format, on the responses received from their family doctor (general practitioner) or paediatrician, when they first voiced concern about the child's development. Responses were collapsed into four categories: (1) ambivalence ('nothing to worry about', 'every child develops differently'), (2) shy/anxious, (3) another issue identified (i.e., not ASD), and (4) ASD symptoms recognised or diagnosis given. A logistic regression, controlling for age, showed that responses given from medical professionals did not significantly predict sex, *Wald*(3) = 2.11, $p = .55$. For 42% ($n = 24$) of girls and 30% ($n = 26$) of boys respondents reported 'ambivalence' as the initial response from a medical professional, while 33% ($n = 19$) of girls and 41% ($n = 36$) of boys had another diagnosis queried. At the point where parents first expressed concern, ASD symptoms were queried or identified in only 21% ($n = 12$) of girls and 24% ($n = 21$) of boys. Finally, for only 4% ($n = 2$) girls and 6% ($n = 5$) boy the initial response was that the child was anxious or shy. As such, regardless of sex, the first response to parent concern was typically either ambivalence, or another diagnosis (i.e., not ASD) was queried.

Other diagnoses queried. Parents free-reported on other diagnosis queried by medical professionals during the pre-school years. Results did not significantly predict sex, *Wald*(4) = 6.48, $p = .17$. The most common 'other' diagnosis queried was attention deficit hyperactivity disorder (ADHD; 24%, $n = 12$ girls, 32%, $n = 26$ boys). Language disorder was first queried for 28% of girls ($n = 14$) and 15% of boys ($n = 12$). Anxiety (12%, $n = 6$ girls and 10%, $n = 8$ boys) and global development delay (6%, $n = 3$ girls and 16%, $n = 13$ boys) were also reported by respondents. No other diagnosis was queried for 31% of girls ($n = 16$) and 27% of boys ($n = 22$).

Discussion

Research has shown substantial sex differences in both the rate and timing of an ASD diagnosis, with cognitively able girls with ASD diagnosed less and later than males (Begeer, et al., 2012; Rivet & Matson, 2011). The purpose of this study was to explore reasons for why ASD may be more difficult to identify in girls, and thus whether the sex discrepancy in the diagnostic rates of ASD may represent an under-detection of the disorder in girls. The study particularly focussed on sex differences in the pre-diagnosis concerns held for the development of children who were later diagnosed with ASD. I specifically targeted those children who, despite early concerns, were not diagnosed until school age. Results revealed that sex differences were evident across specific social concerns (externalising versus internalising), early signs (such as imitation), social strategies, and types of restricted interests. Results provide insight into why it may be more difficult to detect the early-signs of ASD in girls and suggest the current sex difference in the diagnostic rates may not represent a true prevalence difference, at least not of a magnitude of 4-10 boys to 1 girl.

Sex Differences on the Social Domain

Attwood and colleagues (2006) suggested that ASD is more difficult to detect in cognitively able girls due to their ability to use compensatory strategies that camouflage their impairments. Results provide preliminary support for this hypothesis. Based on parent report, girls were substantially more likely to engage in ‘active’ strategies to navigate social environments, the most common of which was mimicking observed social interactions in an attempt to ‘fit in’ socially. This mimicking behaviour included reports of copying adult interactions, peer interactions, or social interactions seen on television or in movies. Beyond mimicking, only a handful of girls were reported to use isolation to manage social settings. In contrast, isolation was a more commonly reported

strategy for boys, with almost a third of boys reportedly isolating or withdrawing themselves from preschool social settings. The ability to mimic social interactions, along with girls' superior imitation ability, could lead to girls presenting as seemingly more social. This may, in turn, make it more difficult to identify girls' underlying social impairments (e.g., lack of understanding of social cues). These social impairments then likely become more salient when socialising becomes more complex during later childhood or adolescence.

Besides an ability to camouflage impairments, results also suggest some of the key early signs of ASD present differently in girls and boys, likely further compounding the difficulty identifying ASD in girls. These signs included the ability to engage in complex imitation and having an unusually strong desire to fit in with peers, both of which were more common in girls. These differences, for girls who go on to meet criteria for ASD, may affect their presentation in two ways. First, better imitation likely assists girls in engaging in the more active compensatory strategies discussed earlier. That is, being able to engage in more complex imitation likely assists girls in effectively mimicking social interactions (at least in the pre-school years). Second, the absence of early 'typical' signs of ASD potentially makes the disorder more difficult to detect in pre-school aged girls. This not only includes imitation complexity but also the finding that more girls present as desperate to fit in socially with their same-aged peers. This is in line with case reports presented by Kopp and Gillberg (1992) where it was noted that girls seemed to present as excessively clingy rather than withdrawn. Again, this more 'active' social behaviour potentially makes it more difficult to early identify underlying social impairments.

A surprising finding regarding concerns for social development was that externalising behaviour was of greater concern for girls than boys. While around half of

the reports on girls identified externalising behaviour as the primary social concern, this was the case for only a quarter of boys. In particular, concerns with externalising behaviour commonly related to the child's strong desire to maintain stringent control over the play, with resulting 'melt-downs' if rules were not followed. While this finding may be impacted by such factors as expectations of how boys and girls should socialise, it does indicate, that at least from the parent's perspective, introversion or isolating behaviours were not a key reason for why girls were diagnosed later. That said, this study does not rule out the possibility that girls presented as more introverted in a pre-school (teacher-observed) setting rather than parent-observed social setting. Indeed, finding that teachers were less concerned with girls than boys, coupled with evidence of boys with ASD showing more externalising behaviour at school (Dworzynski et al., 2012; Mandy et al., 2012) suggest home and school presentation may be starkly different for girls with ASD. This idea will be explored further in the next chapter of this thesis.

Sex Differences in Restricted Interests

In further support of the camouflage hypothesis were differences in the types of restricted interests held by boys and girls. Research suggests girls present with fewer restricted/repetitive behaviours to boys (Lord, et al., 1982; Mandy, et al., 2012). However, my analysis of the type of restricted interest of most concern to caregivers, suggests it is possibly the nature, rather the frequency of the interest that differs. The majority of parents of boys reported their primary concern regarding early restricted interests was the boys' nonfunctional use of wheeled toys (e.g., fixation with spinning wheels, lining up of cars). These behaviours may be considered in line with the stereotyped 'look' of ASD. In contrast, this was only a concern for two girls. Girls reportedly showed more restricted interests around their toys (e.g., lining up of teddy

bears) or random objects (such as collecting shells or feathers). While this may reflect the type of toys available to young girls and boys, it does show that, as suggested by Attwood and colleagues (2006), many girls do not present with restricted interests that may be considered 'typically autistic' or readily recognised as an early sign of abnormality. Those interests shown by girls may make it more difficult for parents and/or professionals to distinguish between typical and atypical interests (particularly in the pre-school years). If it is more difficult to identify restricted interests in girls, it may mean current knowledge on sex differences in the presence of restricted interests, (where girls present with substantially less) may be inflated, due to the under-recognition of how these interests may manifest in females. Again, the atypical nature of these restricted interests may then not become salient until the school years, when the girls' interests may become less age appropriate. Further research as to medical professionals' expectations of what restricted interests in ASD 'looks like' and how girls' and boys' fixated interests would be identified by these professionals, would be a useful avenue for exploration.

Conclusion

Results from this study have provided insight into why high-functioning ASD may be more difficult to detect early in females relative to males. This is the first study to investigate sex differences in pre-school social compensatory strategies used by children who go on to receive an ASD diagnosis. From this I provided preliminary support for the camouflage hypothesis. That is, engaging in mimicking behaviour to navigate pre-school social situations did predict being a girl who would go on to be diagnosed with ASD, as was a broader ability to engage in more complex imitation. I also provided evidence that the symptom presentation, from parent perspective, was different for boys versus girls. Parents expressed fewer concerns for girls' language

skills, desire to be liked, and interests in parts of objects. Further, girls and boys appeared to present with substantially different restricted interests, with girls' interests potentially more difficult to detect as atypical (or indeed as a sign of ASD). Results suggest girls are more active in their attempts for social engagement and present with more subtle restricted interests, potentially making the disorder more difficult to identify in pre-school aged girls.

Limitations and Future Directions

This study investigated caregivers' perspectives on early concerns for the child's development. In doing so, I wished to investigate whether any sex differences in early concerns may have led parents, teachers or medical professionals to have more difficulty identifying ASD in girls. Nevertheless, I acknowledge some limitations to this study that may have impacted the results. Primarily, the study relies on retrospective self-reporting and the use of an unstandardized online survey, with diagnosis also not reconfirmed. However, an advantage of the online survey format was our ability to access a larger sample of girls than is commonly seen in the literature on sex differences. Further, results lend to many fruitful paths for further exploration of reasons for the sex differences in the age and prevalence of ASD diagnosis in cognitively able children. One useful avenue would be to explore the pre-diagnosis concerns of boys and girls who were late- versus early-diagnosed with ASD. The difficulty with this design would be the recruitment of cognitively-able girls with ASD who were diagnosed early (i.e., before school age). Nevertheless it would provide interesting information on differences unique to the many cognitively-able girls who are later-diagnosed with ASD. Also of use would be the replication of this research exploring current behaviours of samples of children with ASD. In particular, this would provide insight, from trained clinicians' perspectives, into how ASD may present

differently at the point of diagnosis. Exploring this is the aim of the next study presented in this thesis. In particular, I remain interested in furthering understanding of school versus home presentation of boys and girls, based on teacher, parent and clinician report. Primarily, I also further explored how the overt behavioural presentation of ASD in girls, may make the disorder more difficult to identify.

Chapter 5: Study 3

Sex Differences in Autism Spectrum Disorder based on DSM-5 Criteria: Evidence from Clinician and Teacher Reporting[18]

This study, the final presented in this thesis, was designed to investigate sex differences in the presentation of cognitively-able children and adolescents with ASD, based on both DSM-IV-TR and DSM-5 criteria. In this study I have investigated how girls and boys came to meet criteria for ASD. That is, what impairments were, and were not present, that resulted in the child being diagnosed with ASD. Broadly, this study had three key aims. First, I primarily explored whether girls with ASD presented with different overt behaviours to boys, which may act to mask the underlying social impairment and make diagnosis more difficult. Overt behaviours were those considered readily observable by a parent or professional, such as nonverbal gestures, obsessional interests, and friendships. Second, based on the results of chapter 4, I also further investigated sex differences in imitation abilities, and types of restricted interests, this time in a sample a cognitively-able children and teens with a current diagnosis of ASD. Third, I explored how girls' and boys' presentations may differ between different settings, through a comparison of clinician versus teacher report on the child's behavioural presentations. While Chapter 4 focussed on parent report of pre-diagnosis concerns, here I have focussed on both clinician and teacher report of functioning at the time of diagnosis, to further our understanding of sex differences in the behaviour presentation of cognitively-able children with ASD.

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[18] A large proportion of this chapter comes from Hiller, R. M., Young, R., & Weber, N. Sex differences in autism spectrum disorder based on DSM-5 criteria. *The Journal of Abnormal Child Psychology.* In Press.

In this study I also target the impact of the DSM-5 on the diagnosis of ASD for girls. In 2013 the fifth edition of the diagnostic statistical manual was released (DSM-5), and represented a significant change in how we conceptualise and diagnose autism. The DSM-5 saw Asperger's Disorder, Autistic Disorder, Childhood Disintegrative Disorder, and Pervasive Developmental Disorder Not Otherwise Specified (PDD NOS) combined under the umbrella term of Autism Spectrum Disorder. Most notably, for the female profile of ASD, the DSM-5 makes specific reference to clinician's being aware that females with ASD may present differently to the 'typical' male presentation of the disorder. This represents a positive step in identifying to clinicians that the disorder may present differently in girls. However, research is yet to provide much insight into what exactly these differences may be. Further, it is not yet clear how changes in the DSM-5 diagnostic criteria may affect the diagnosis of girls, particularly given its more rigid requirement of meeting all three social impairment criteria to receive a diagnosis. In the study presented in this chapter I have drawn on both the DSM-IV-TR and DSM-5 to provide a comprehensive examination of the presentation of girls with ASD. Consequently, this is the first study to examine sex differences in the context of the new DSM-5 criteria, and thus also allowed me to explore how changes in these new criteria may impact the diagnosis of girls.

Under the broad diagnostic categories provided by either the DSM-IV-TR or DSM-5 there are a range of potential impairments which are potentially considered by family doctors, paediatricians, and later, diagnostic clinicians, when assessing the likelihood that a developmental concern is ASD. These include more readily identifiable overt behaviours (e.g., failure to maintain eye contact, difficulty making friends, inability to deal with change), underlying impairments (e.g., lack of reciprocal social understanding), and broader features commonly associated with ASD but not

unique to the disorder (e.g., cognitive deficits, problems with imitation). All factors (regardless of whether they represent a DSM criteria) potentially lend to the overt behaviour presentation of ASD in the individual. In this thesis I have theorised that, for girls, this 'look' may be different from what is considered the 'typical' presentation of ASD, resulting in potential signs or underlying impairments being missed (or misdiagnosed).

Research on sex differences in the core symptoms of ASD presents inconsistent results. The most consistent findings is that girls are less likely than boys to present with restricted interests (Hartley & Sikora, 2009; Lord, et al., 1982; Mandy, et al., 2012; Szatmari, et al., 2012), with Szatmari and colleagues (2012) suggesting this may be due to girls' higher genetic liability. However, on the DSM-IV-TR the individual must meet only one of four potential impairments on the restricted/repetitive behaviours domain, while on the DSM-5 the individual must meet two of four potential criteria. Consequently, it seems unlikely that differences in restricted interests alone, would provide a robust explanation for the under-identification of girls. Sex differences on the social and communication domain have remained inconsistent. The literature shows evidence of no difference (Andersson, et al., 2013; Mandy, et al., 2012), more severe (Hartley & Sikora, 2009; McLennan, et al., 1993) and less severe (Lai, et al., 2011) social impairment in females, compared to males with ASD. A recent study by Mandy and colleagues, which employed a larger sample of girls ($N = 52$), who were all considered cognitively-able, found evidence of no significant sex differences in the broad social criteria for ASD, based on DSM-IV-TR. Currently, our ability to draw conclusions from these studies has thus far been limited by methodological issues, including small samples (particularly of females, given the practical difficulty of recruiting cognitively-able girls with ASD) and the reliance on retrospective reporting

after large time lapses (in some cases up to 40 years; Lai et al., 2011). Moreover, in an aim to overcome difficulties recruiting girls with ASD, some studies have relied on samples of children with intellectual impairment (e.g., Andersson, et al., 2013), making it difficult to determine what is unique to ASD, in cognitively-able samples, which may make the disorder more difficult to identify in girls. In this study I have overcome these limitations with a larger sample of cognitively-able girls with ASD, all diagnosed with ASD (i.e., without comorbid intellectual disability), along with a focus on the child's state of functioning at the time of the diagnosis.

While it is certainly worthwhile to explore sex differences in the broader ASD criteria provided by the diagnostic manual, it is perhaps not surprising that little sex differences are often reported. Specifically, this is because the samples have included individuals who have already been diagnosed with the disorder, and thus met criteria. However, within each broad criteria there are a range different behaviours a clinician may draw on to decide whether a child does or does not meet a particular criterion. For example, to meet impairment in nonverbal communicative behaviour the child may present with impairments in their integration of verbal and nonverbal behaviours, or impairments in eye contact or social smiling, or impairment in their understanding of nonverbal cues. An individual may present with one, some, or all of these behaviours to meet the particular criterion. However, the literature fails to provide insight into how girls and boys come to meet each criterion, as outlined in either DSM-IV-TR or DSM-5. Explaining this could provide much insight into why the diagnosis may be more difficult to detect in girls, particularly by professionals not trained in making a diagnosis, yet likely to be the first source of information relied on by a parent (e.g., family doctor, teachers). Consequently, a key aim of this study was to move beyond examination of the broad criteria to explore whether there were sex differences in the

way boys and girls came to meet each criterion for ASD. In particular, I explored whether sex differences in overt behaviours would be present, despite equally impaired underlying understanding. That is, are girls potentially able to camouflage (either consciously or unconsciously) their underlying impairments?

It has been proposed that ASD may be particularly difficult to identify in girls due to impairments not presenting consistently across settings (Attwood, et al., 2006; Dworzynski, et al., 2012; Mandy, et al., 2012). In particular it has been suggested that girls' underlying social impairment would be even less salient in a school environment (Attwood, et al., 2006). Supporting this hypothesis, in Chapter 4, parents of girls were more likely to report no teacher had ever raised concern for their child's development or behaviour. In comparison, teachers expressed concern for all but two boys. This concern for boys was also generally expressed in the pre-school years. Lack of teacher concern for girls was also at odds with evidence that parents of girls were actually more concerned with their child's externalising behaviours than parents of boys. This provides initial insight into the idea that girls' externalising behaviours do not seem to manifest across different settings, particularly in a school context. This was supported in recent studies by Mandy et al. (2012) and Dworzynski et al. (2012), who both found that teachers rated girls with ASD as having better social skills (e.g., better prosocial behaviour), despite no significant difference in parent ratings (Dworzynski et al., 2012) or indeed greater parental concern for girls (Mandy, et al., 2012). In the more comprehensive study by Mandy and colleagues, teacher's reported that boys with ASD were more problematic than girls overall, and had more problems with hyperactivity, prosocial behaviour, and peer relationships. This was in contrast to parent report of more concern for the emotional symptoms of girls. These findings suggest that girls are somehow able to hide emotional symptoms, and social impairments, often witnessed by

parents, when in a school environment. Girls' potential ability to manage their behaviours in large social settings (i.e., school), despite impairments, provides important insight in to why the disorder may be more difficult to detect in this population. Consequently, an additional aim of this study was to further explore teacher reporting on the presentation of boys and girls. Specifically, I compared sex differences in clinician report versus teacher reporting of the child's presentation to further explore how girls presented differently when in a school environment.

In sum, this study was designed to investigate sex differences in the presentation of children and adolescents with ASD, based on both DSM-IV-TR and DSM-5 criteria. As such, this study investigated whether sex differences in the diagnostic rates may be, at least in part, due to girls being able to hide their impairments, leading to the under-detection of the disorder. To explore this I examined the diagnostic assessments and reports of cognitively able children and adolescents who had all been diagnosed with ASD. The inclusion of both DSM criteria also allowed for the investigation of the impact of the DSM-5 criteria on the diagnosis of girls. Within the DSM-5 framework this study moved beyond the examination of sex differences in the broader diagnostic categories of ASD, and allowed me to examine whether there were sex differences in what specific impairments, within each criterion, resulted in the clinician determining that the child met criteria for ASD. Broader signs of ASD, such as imitation, were also investigated, in line with evidence from Chapter 4 of girls' reported superior imitation ability, and the potential importance of this skill in contributing to a different presentation of ASD in girls (Attwood et al., 2006; Kopp & Gillberg, 1992). This information, along with differences in the home versus school-presentation of girls and boys with ASD, allowed for me to further explore how ASD may present differently in

girls and boys, and, importantly, how these differences may manifest across different settings.

Method

Participants

Information was gathered from the diagnostic assessments and resulting reports of 69 girls and 69 boys. See Table 5.1 for information on age of participants. The participants were clients from a large private practice in Adelaide, South Australia, specialising in diagnostic assessments for Pervasive Developmental Disorders (PDDs). All clinicians had specialised training in PDD assessment and were recognised diagnosticians with the local Autism organisation. Informed consent was provided by the parent (and child where appropriate) for use of their diagnostic data for research purposes, as part of the standard process of the practice. A total of five clinicians contributed participant information to the current study (4 psychologists and 1 speech pathologist). Assessments included both dual assessments (by a psychologist and a speech pathologist) and single assessments (by a sole practitioner), depending on the need of the client.

Table 5.1

Age and IQ (standard scores) data for Boys and Girls

Descriptive	Girls	Boys	Significance of group difference
Age diagnosed (years)			
M(*SD*)	8.06 (4.03)	8.76 (3.91)	$t = 1.03$, $p = .31$, $d = .17$
Range	1.58 – 16.92	2.16 – 16.58	-
Full-scale IQ			
M(*SD*)	97.76 (15.31)	100.31 (13.27)	$t = 0.74$, $p = .46$, $d = .18$
Verbal IQ			
M(*SD*)	96.91 (11.99)	100.89 (12.71)	$t = 1.55$, $p = .12$, $d = .32$
Performance IQ			
M(*SD*)	100.19 (13.38)	103.30 (15.64)	$t = 1.02$, $p = .31$, $d = .21$

Note. No child in this sample had an IQ in the range considered intellectually disabled (below the second percentile).

Diagnostic process. For 114 participants (81%), the diagnostic clinician referred to both the DSM-IV-TR (American Psychiatric Association, 2000) and DSM-5 (American Psychiatric Association, 2013) criteria in the resulting diagnostic report, as was standard practice of the clinic due to a transition period between the two criteria. See figure 5.1 for information on how many boys and girls had information from the primary sources from which data was collected. Due to the timing of the assessments the DSM-IV-TR was used to make the official diagnosis.

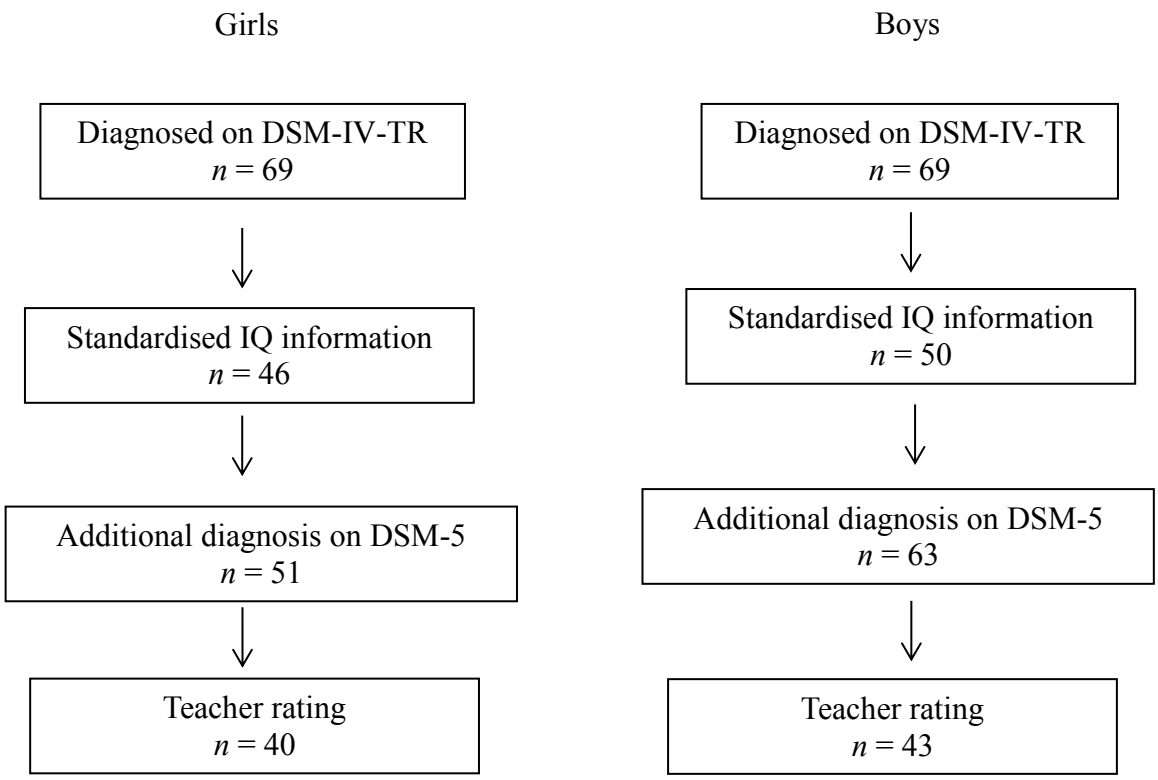

Figure 5.1. Number of girls and boys who had information from the various primary sources.

In conjunction with the DSM-IV-TR criteria, a variety of standardised assessments were used to determine diagnosis. On the DSM-IV-TR and DSM-5 criteria participants were rated by the diagnostic clinician as either meeting the criterion (Yes), partially meeting the criterion (somewhat), or not meeting the criterion (No). For the purpose of the final diagnostic decision, only somewhat meeting a criterion meant the criterion was not actually met, but that the clinician had identified some atypicality. Consequently, the clinician's use of these three rating levels allowed me to gain more insight into when a clinician identified an impairment as atypical, but not at a level to constitute meeting the criterion. All clinician's followed a standard report structure where each diagnostic criterion was referred to, with a breakdown of what behaviours the child presented with (and what impairments were not, or only partially present),

within each criterion. Available information from the diagnostic file was also used (e.g., questionnaires) to ensure information in the report was consistent with information collected during the diagnostic assessment. As information was collected from the assessments of five independent clinicians, and a broad range of ages of clients, different assessment tools were used and as such will not be compared in this study. However, all assessments comprised a formal diagnostic interview with the child and parent, which followed a standard procedure, as per the clinic's protocol. Other measures used included the Autism Detection in Early Childhood (ADEC; R. L. Young, 2007), the Childhood Autism Rating Scale (CARS; Schopler, Reichler, & Renner, 1986), the Autism Diagnostic Interview-Revised (ADI-R; Lord, Rutter, & Le Couteur, 1994), and the Autism Detection Observation Schedule (ADOS; Lord, et al., 1989). As a variety of different assessment tools were used, data from these tools will not be analysed in this study.

Diagnoses. Chi square analysis showed no significant difference (with small effect size) in the diagnostic categories met by the girls and boys, $\chi^2(3) = 2.48$. $p = .48$, $\phi_c = .13$. The most common category was Asperger's Disorder (based on DSM-IV-TR), with 73.9% ($n = 51$) of girls and 78.3% ($n = 54$) boys meeting this criterion. Ten girls (14.5%) and 9 boys (13.0%) were diagnosed with Autistic Disorder or Autism Spectrum Disorder, while the remaining 8 girls (11.6%) and 6 boys (8.7%) met criteria for pervasive developmental disorder (not otherwise specified; PDD-NOS).

IQ information. Standardised IQ data from the Wechsler Intelligence Scale for Children (Wechsler, 2003), or the Wechsler Preschool and Primary Scale of Intelligence (Wechsler, 2002), were available for 97 children (69%). There was no significant difference (with small effect sizes) in the age, full-, verbal-, or performance-IQ of the boys and girls (see Table 5.1). All participants for whom IQ data were available had

either performance- or verbal IQ in the average range (or above). No participant's verbal- or performance-IQ was below the standard score of 70 (or below the second percentile). Verbal IQ scores ranged from 77 to 135, while performance IQ scores ranged from 72 to 143. It was assumed that the participants for whom IQ data were not available did not have an intellectual impairment as all were functioning academically in a mainstream school or had previously scored in the 'competent' range for cognition using the Bayley Scales of Infant and Toddler Development (Bayley, 2006). .

Previous diagnosis. Eighty-three participants (n = 60) had a reported previous diagnosis, prior to the ASD assessment (43 boys and 40 girls). Chi square analysis showed a significant sex difference in previous diagnoses, $\chi^2(3) = 22.16$, $p < .001$, $\phi_c = .46$. For boys, the most common previous diagnosis was either ADHD or significant behaviour problems (74.4%, n = 32), with only 25.0% of girls (n = 10) having previously received this diagnosis. Thirteen of the girls (32.5%, n = 13) had a previous anxiety disorder diagnosis, compared to only 7% of boys (n = 3). The other categories were sensory or language disorders (girls: 27.5%, n = 11; boys: 16.3%, n = 7), and a previous diagnosis of PDD-NOS (girls: 15%, n = 6; boys: 2.3%, n = 1).

Family history. Information on family history of ASD was available for 61 girls and 57 boys. Chi square analysis showed no significant sex difference in family history, $X^2 = 4.46$, $p = .10$, $\phi_c = .19$. Approximately half of all children had no family member with a known diagnosis of ASD (girls: 45.9%, n = 28; boys: 59.6%, n = 34). Forty one per cent of girls (n = 25) had an immediate family member (parent or sibling) with an ASD diagnosis, compared to 22.8% of boys (n = 13). The remaining 13.1% of girls (n = 8) and 17.5% of boys(n = 10) had some other member of their extended family with an ASD diagnosis (e.g., uncle or cousin).

Procedure

A research assistant and I examined the diagnostic assessment information and resulting diagnostic reports for all children. Clinician rated information was collected on the DSM-IV-TR and DSM-5 criteria. Additional information provided in the report and diagnostic interview was collected verbatim and applied to the various behaviours of interest, which are listed in Table 5.2, with corresponding odds ratios and 95% confidence intervals. These behaviours were extrapolated from the various behaviours outlined within the DSM-5 criteria (American Psychiatric Association, 2013). Each behavioural impairment was later coded as either (0) no impairment, (1) partially or somewhat impaired, and (2) impaired. The specific presentations that constituted somewhat impaired versus impairment or not impaired will be discussed in the results section, where variables are described in more detail. Importantly, it was not presumed that the absence of a comment on any behaviour reflected the behaviour not being impaired. Consequently, if a behaviour was not explicitly referred to, the data point was treated as missing. Missing data never exceeded 15% for a given variable, with no difference in the amount of data missing for boys and girls. The only exception to this was references to body language (a potential impairment from the nonverbal behaviour category), which was rarely referred to in reports and has thus not been included in the analysis. On entry of data, care was taken to remove reference to sex (e.g., ‘her’, ‘his’). Hence, I later coded information blind to the sex of the child. An independent rater, blind to the child’s sex and the research aims then completed interrater reliability on 30% of the data. Adequate interrater reliability was established across all variables based on Cohen’s kappa scores between .75 and .92.

Information was also gathered on imitation abilities. I was most interested, not in whether the child could or could not imitate, but whether they could generalise this

imitation skill for social gain. Imitation for social gain was established from references such as the child using mimicking of social interactions to try and engage in conversation with peers (coded as 2). If the child was able to imitate but did not generalise this skill to a social context it was coded as 1. This included explicit reference to basic imitation but not used in a social context, or reference to mimicking movie lines but completely out of social context. Having no ability to imitate was coded as 0.

School presentation was taken from two sources. First, as part of the standard pre-diagnosis questionnaire, parents reported on what concerns were expressed to them when their child was in pre-school. Second, the child's current teacher reported on a range of behaviours, based on a structured written interview provided to teachers as part of the clinic's standard procedure. Again, information was collected verbatim from the reports, including reference to the child's social functioning, externalising behaviours, friendships, restricted interests, and atypical movements. Results were coded as either 0 (not problematic), 1 (somewhat problematic), or 2 (problematic). This information was again coded by the primary researcher, as well as the independent rater (for 30% of the sample).

Table 5.2

Results of Logistic Regression Analyses, Controlling for Age, for the Behaviour Predicting Sex

Criterion	Behaviour	Chi-square(*df*)	*ExpB* [95% CI]		
		Overall	Criteria Not Met	Criteria Somewhat Met	Criteria Met (constant)
Social-emotional reciprocity	Social approach**	6.64(2)	6.93 [0.76, 62.90]	2.45** [1.06, 5.70]	1.16 [0.45, 2.97]
	Reciprocal conversation*	23.90(2)	25.54* [3.05, 214.11]	6.79* [2.83, 16.32]	0.55 [0.18, 1.68]
	Sharing of interests*	9.70(2)	4.66* [1.70, 12.81]	1.23 [0.53, 2.84]	0.82 [0.29, 2.34]
	Emotion and affect	9.33(2)	-[a]	0.68 [0.39, 2.22]	1.21 [0.47, 3.10]
	Initiation of interaction	5.43(2)	-[b]	3.29** [1.21, 8.93]	1.87 [0.75, 4.71]
Non-verbal communicative behaviour	Integration of verbal/nonverbal behaviour*	9.14(2)	4.94* [1.67, 14.61]	1.05 [0.43, 2.55]	0.84 [0.28, 2.48]
	Eye contact	4.14(2)	2.55** [1.02, 6.39]	1.14 [0.50, 2.59]	1.14 [0.45, 2.86]
	Facial expressions	1.88(2)	1.67 [0.52, 5.31]	1.69 [0.72, 3.93]	1.08 [0.43, 2.69]

	Nonverbal understanding	0.31(2)	- [c]	1.40	0.81
				[0.43, 4.53]	[0.29, 2.27]
Developing and maintaining friendships	Adjusting behaviour for situation*	16.22(2)	17.17*	12.57*	0.53
			[2.08, 141.99]	[2.62, 59.48]	[0.23, 1.93]
	Sharing behaviour	5.18(2)	4.85**	1.22	1.13
			[1.24, 18.88]	[0.54, 2.73]	[0.46, 2.77]
	Imagination*	17.13(2)	6.10*	4.23*	0.60
			[2.42, 15.39]	[1.64, 11.23]	[0.21, 1.68]
	Making friends*	9.40(2)	4.03	3.10*	1.11
			[0.90, 18.02]	[1.42, 6.74]	[0.47, 2.66]
	Interest in people**	8.74(1)	3.13**	-	0.60*
			[1.44, 6.76]		[0.37, 0.96]
Stereotyped/repetitive behaviour	Speech	2.45(2)	2.01	1.10	1.02
			[0.79, 5.11]	[0.48, 2.52]	[0.37, 2.83]
	Movement	4.14(2)	2.53	1.79	0.80
			[0.99, 6.45]	[0.81, 3.93]	[0.30, 2.10]
	Use of objects*	9.68(2)	6.38*	0.96	1.36
			[1.90, 21.41]	[0.42, 2.17]	[0.57, 3.25]
Excessive routine adherence	Routine adherence	3.29(2)	0.23	0.96	1.49
			[0.05, 1.13]	[0.42, 2.19]	[0.63, 3.53]
	Managing change	1.93(2)	0.47	1.43	1.52

			[0.11, 2.06]	[0.61, 3.37)	[0.62, 3.71]
Restricted/fixated interest[d]	Type of interest	-	-	-	-
Sensory sensitivity		2.17(2)	3.04	1.18	1.38
			[0.69, 13.38]	[0.49, 2.84]	[0.55, 3.46]

Note. 95% CI for *ExpB* calculated from *B(SE)* and converted for ease of interpretation

[a] Only six children failed to meet criteria on emotion/affect category (all of whom were girls). [b] Only four children (all girls) failed to meet criteria on initiation category. [c] Six children (all girls) failed to meet criteria for nonverbal understanding. [d] For restricted/fixated interests data was coded by type or category of impairment (results in Table 5.8).

*Overall model and levels which significantly predicted sex based on $p \leq .01$; ** $p \leq .04$

Statistical Analysis

As presented in Chapter 4, I primarily used logistic regression analyses to allow me to determine whether the presence (or absence) of a specific impairment could predict whether a child with ASD was a boy or girl. In all regressions sex (boy – 0, girl – 1) was the outcome variable. Age was controlled for in all variables.[19] Response options on each DSM criterion, as rated by the diagnostic clinician, were (i) criterion not met (i.e., no impairment), (ii) criterion somewhat/partially met, (iii) criterion met (i.e., significantly impaired). These same response options were used to code each behaviour. The predicted odds ratio for a specific response level shows the likelihood that a participant at this response level was a girl versus boy with ASD. Predicted odds ratios are asymmetrical around 1, meaning it is difficult to interpret odds ratios favouring girls (>1) with those favouring boys (<1). Consequently, I transformed all odds ratios to >1 and have noted whether the ratio describes the likelihood of being a girl or a boy. Details of this procedure have been outlined in the previous chapter.

Results

Sex Differences Based on DSM-IV-TR Criteria

As the majority of the sample met criteria for Asperger's Disorder, I investigated sex differences based on the diagnostic criteria for this disorder (i.e., the social and ritualistic domains only; American Psychiatric Association, 2000).

Social domain. Results of logistic regressions for DSM-IV-TR criteria are presented in Table 5.3, with the percentage of children to meet each criteria presented in Table 5.4. On the social domain, there was no evidence of an overall significant sex

[19] IQ failed to significantly correlated with any variable (with the highest correlation being r = .17). However, to be conservative, data was also analysed controlling for IQ, however this had no effect on the pattern of results.

difference on the nonverbal behaviours and sharing interests criterion. Examination of the various levels of these categories (criteria met, somewhat, not met) showed meeting criteria for significant impairment on either of these criterion did not significantly predict sex. However, only partially or somewhat meeting criterion on the nonverbal impairment category and not meeting criteria on the sharing of interests criterion, both significantly predicted the child was a girl. As such, girls were more likely than boys, to show only partial impairment in nonverbal skills and no impairment in their apparent sharing of interests. On the peer relationships and social/emotional reciprocity criteria, the overall logistic regression model showed level of impairment was not predictive of sex.

Repetitive/restricted interests domain. On this domain, the only category to significantly predict sex was the presence of restricted or fixated interests (see Table 5.3). If a child failed to meet this criterion, the predicted odds ratio showed the child was 10 times more likely to be a girl than boy. As such, not meeting criteria was significantly predictive of being a girl. Routine adherence, stereotyped movement, and preoccupation with parts of objects all failed to significantly predict sex (see Table 5.3).

Table 5.3

Results of Logistic Regressions for DSM-IV-TR Categories Predicting Sex, After Controlling for Age

Category	Predicted Odds	*Wald*(*df*)	*p*	*ExpB* [95% CI]
Nonverbal impairment		5.33(2)	.07	
Criteria not met	1.65	1.11(1)	.29	1.94 [0.56, 6.07]
Somewhat**	2.07	4.98(1)	.03	2.43 [1.11, 5.30]
Criteria met (constant)	1.17	0.13(1)	.72	.85 [0.34, 2.08]
Failure to develop peer relations		2.15(2)	.34	
Criteria not met	1.37	0.04(1)	.84	1.22 [0.17, 9.06]
Somewhat	2.20	2.14(1)	.14	1.97 [0.79, 4.91]
Criteria met (constant)	1.12	0.08(1)	.79	1.12 [0.49, 2.56]
Impairment in sharing of interests		5.44(2)	.07	
Criteria not met**	1.86	5.03(1)	.03	2.52 [1.13, 5.74]
Somewhat	1.05	0.31(1)	.58	1.29 [0.52, 3.20]
Criteria met (constant)	1.35	0.36(1)	.55	.74 [0.26, 2.01]
Lack of social and emotional reciprocity		0.01(2)	.99	
Criteria not met[a]	-	0.00(1)	1.00	-
Somewhat	1.33	0.01(1)	.94	0.97 [0.37, 2.54]
Criteria met (constant)	1.38	0.55(1)	.46	1.38 [0.59, 3.22]
Restricted interest*		20.85(2)	<.001	
Criteria not met*	8.32	9.65(1)	<.01	29.72 [3.50, 252.71]
Somewhat*	2.30	14.48(1)	<.001	8.20 [2.77, 24.23]

Criteria met (constant)	3.57	5.20(1)	.02	0.28 [0.09, 0.84]
Inflexible routine adherence		2.69(2)	.26	
Criteria not met	1.08	0.87(1)	.35	0.59 [0.19, 1.80]
Somewhat	1.23	2.23(1)	.14	0.52 [0.22, 1.23]
Criteria met (constant)	1.56	1.11(1)	.29	1.56 [0.68, 3.56]
Stereotyped motor mannerisms		2.15(2)	.34	
Criteria not met	2.00	0.63(1)	.43	1.43 [0.59, 3.50]
Somewhat	1.01	0.67(1)	.41	0.72 [0.33, 1.59]
Criteria met (constant)	1.40	0.61(1)	.44	1.40 [0.60, 3.22]
Persistent preoccupation with parts		4.88(2)	.09	
Criteria not met	2.18	2.23(1)	.14	1.79 [0.83, 3.86]
Somewhat	1.39	1.08(1)	.30	0.59 [0.22, 1.59]
Criteria met (constant)	1.22	0.20(1)	.65	1.22 [0.52, 2.86]

Note. CI = confidence interval, underlined predicted odds ratios represent odds predictive of being a girl with ASD

[a] Only one child failed to meet impairment in social and emotional reciprocity based on DSM-IV-TR criteria.

*$p < .01$, ** $p < .05$

Table 5.4

Percentage of Girls and Boys Who Either Met, Partially Met, or Did Not Meet Each DSM-IV-TR Criteria, Based on Clinician Ratings

Category	Girls % (*n*)	Boys % (*n*)
Nonverbal impairment		
Criteria not met	10.4 (7)	7.2 (5)
Somewhat	38.8 (26)	21.7 (15)
Criteria met (constant)	50.7 (34)	71.0 (49)
Failure to develop peer relations		
Criteria not met	3.0 (2)	2.9 (2)
Somewhat	22.7 (15)	13.0 (9)
Criteria met (constant)	74.2 (49)	84.1 (58)
Impairment in sharing of interests		
Criteria not met	52.2 (35)	31.9 (22)
Somewhat	22.4 (15)	27.5 (19)
Criteria met (constant)	25.4 (17)	40.6 (28)
Lack of social and emotional reciprocity		
Criteria not met[a]	1.5 (1)	0 (0)
Somewhat	14.9 (10)	14.5 (10)
Criteria met (constant)	83.6 (56)	85.5 (59)
Restricted interest*		
Criteria not met*	17.9 (12)	1.4 (1)
Somewhat*	31.3 (21)	8.7 (6)
Criteria met (constant)	50.7 (34)	89.9 (62)

Inflexible routine adherence		
Criteria not met	9.0 (6)	13.0 (9)
Somewhat	16.4 (11)	26.1 (18)
Criteria met (constant)	74.6 (50)	60.9 (42)
Stereotyped motor mannerisms		
Criteria not met	26.9 (18)	18.8 (13)
Somewhat	28.4 (19)	39.1 (27)
Criteria met (constant)	44.8 (30)	42.0 (29)
Persistent preoccupation with parts		
Criteria not met	43.4 (29)	27.5 (19)
Somewhat	11.9 (8)	23.2 (16)
Criteria met (constant)	44.8 (30)	49.3 (34)

*$p \leq .01$ based on logistic regression models.

Sex Differences Based on DSM-5 Criteria

Logistic regressions, controlling for age, were also used to assess which broad categories on this new criteria significantly predicted sex. Table 5.5 shows results of the logistic regression analyses, while Table 5.6 presents the percentage of girls and boys who met each criterion. Sixty-three boys (91%) and 51 girls (74%) had clinician-rated information on DSM-5 criteria. From the results of the regression, the only diagnostic category to predict sex was the restricted interest domain. As on the DSM-IV-TR, not meeting or only somewhat meeting criteria for the restricted interest category was predictive of being female.

Table 5.5

Results of Logistic Regression for DSM-5 Criteria Predicting Sex, After Controlling for Age

Criteria	Predicted Odds	*Wald*(*df*)	*p*	*ExpB* [95% CI]
Deficits in social-emotional reciprocity		0.01(2)	.99	
Not met[a]	-	0.00(1)	1.00	-
Somewhat met	1.55	0.01(1)	.93	1.09 [0.14, 8.34]
Met (constant)	1.43	0.58(1)	.45	1.43 [0.57, 3.63]
Deficits in nonverbal communicative behaviour		2.03(2)	.36	
Not met	5.66	1.13(1)	.29	3.52 [0.35, 35.94]
Somewhat met	3.06	1.07(1)	.30	1.90 [0.56, 6.41]
Met (constant)	1.61	0.09(1)	.77	1.61 [0.44, 3.10]
Deficits in relationships		0.08(2)	.96	
Not met	1.68	0.002(1)	.96	1.07 [0.07, 17.61]
Somewhat met	1.32	0.08(1)	.78	0.84 [0.25, 2.86]
Met (constant)	1.57	0.86(1)	.35	1.57 [0.61, 4.06]
Stereotyped/repetitive behaviour		4.64(2)	.10	
Not met	3.54	2.87(1)	.09	2.61 [0.86, 7.90]
Somewhat met	3.26	3.05(1)	.08	2.40 [0.90, 6.42]
Met (constant)	1.36	0.43(1)	.51	1.36 [0.54, 3.46]
Excessive adherence to		4.38(2)	.11	

routines				
Not met	1.96	2.71(1)	.10	0.31 [0.08, 1.25]
Somewhat met	1.21	2.40(1)	.12	0.49 [0.20, 1.21]
Met (constant)	1.68	1.15(1)	.28	1.68 [0.65, 4.35]
Restricted/fixated interest*		11.37(2)	.003	
Not met	4.64	5.07(1)	.02	6.63 [1.28, 34.42]
Somewhat met*	3.42	7.71(1)	.01	4.89 [1.60, 14.97]
Met (constant)	1.42	0.49(1)	.50	0.70 [0.24, 1.99]
Sensory sensitivity		2.17(2)	.34	
Not met	4.20	2.16(1)	.14	3.04 [0.69, 13.38]
Somewhat met	1.63	0.14(1)	.71	1.18 [0.49, 2.84]
Met (constant)	1.38	0.47(1)	.49	1.38 [0.55, 3.46]

Note. Underlined predicted odds ratios represent variable levels predictive of being a girl

[a] Only one child failed to meet criteria for social and emotional reciprocity

* $p \leq .01$

Table 5.6

Percentage of Girls and Boys Who Either Met, Partially Met, or Did Not Meet Each DSM-5 Criteria, Based on Clinician Ratings

Criteria	Girls % (*n*)	Boys % (*n*)
Deficits in social-emotional reciprocity		
Not met	0 (0)	1.6 (1)
Somewhat met	3.9 (2)	3.2 (2)
Met (constant)	96.1 (49)	95.2 (60)
Deficits in nonverbal communicative behaviour		
Not met	5.7 (3)	1.6 (1)
Somewhat met	15.1 (8)	7.9 (5)
Met (constant)	79.2 (42)	90.5 (57)
Deficits in relationships		
Not met	1.9 (1)	1.6 (1)
Somewhat met	9.6 (5)	11.3 (7)
Met (constant)	88.5 (46)	87.1 (54)
Stereotyped/repetitive behaviour		
Not met	19.2 (10)	12.7 (8)
Somewhat met	25.0 (13)	15.9 (10)
Met (constant)	55.8 (29)	71.4 (45)
Excessive adherence to routines		
Not met	5.7 (3)	15.9 (10)
Somewhat met	18.9 (10)	28.6 (18)
Met (constant)	75.5 (40)	55.6 (35)

Restricted/fixated interest*		
Not met	15.1 (8)	3.2 (2)
Somewhat met*	26.4 (14)	7.9 (5)
Met (constant)	58.5 (31)	88.9 (56)
Sensory sensitivity		
Not met	11.5 (6)	4.8 (3)
Somewhat met	25.0 (13)	25.4 (16)
Met (constant)	63.5 (33)	69.8 (44)

* $p \leq .01$ based on logistic regression models.

Sex Differences in Behaviour Presentation

Sex differences in readily observable characteristics on DSM-5. To meet each criterion on either the DSM-IV-TR or DSM-5, the child may present with one (or more) of a number of behaviours of concern. I was interested in whether sex differences may be evident in how boys and girls met criteria (i.e., what impairments within the criterion were present or absent). Regardless of whether the child had clinician-rated information on the broad DSM-5 criteria, information was collected for all participants on these specific finer behaviours mentioned within each criterion. Participants had all met criteria for ASD under the DSM-IV-TR and did not present with comorbid intellectual impairment. Data was collected prior to the official release of the DSM-5, and thus relied on the proposed version, which remained the same in the official DSM-5. Table 5.2 provided a list of all behaviours examined in this study, along with odds ratios and confidence intervals. Results showed numerous areas where girls presented differently to boys, particularly in their more readily observable, overt behaviours. These were the characteristics that I (and the camouflage hypothesis; Attwood et al.,

2006) predicted would suggest girls with ASD 'look' different to boys, thus making the diagnostic process more difficult. Below I discussed in more detail those variables which most strongly predicted sex, based on significance testing ($p < .01$) and effect sizes.

Social and emotional reciprocity. Only one child failed to show any impairment on the DSM-5 social-emotional reciprocity criterion. However, results suggest the impairments that led boys and girls to meet this criteria differed. Girls appeared to present with a greater ability to engage in reciprocal conversation and sharing of interests. If a child/adolescent was able to engage in typical reciprocal conversation they were almost 14 times more likely to be a girl than boy. However, these aparent typical reciprocal conversation skills were only evident for the minority (17%) of girls (and only 1 boy), explaining the large confidence interval (see Table 5.2). Consequently, it was still only the minority of girls with ASD who were able to maintain seemingly typical conversation. If the child appeared to have some ability to engage in conversation they were almost three times more likely to be a girl rather than boy. This category was met by 50% of the girls in the sample (compared to 18% of boys). This 'somewhat' criterion represents those participants who were able to engage in reciprocal conversation but it was primarily on a topic of their own interest, or it was thought social scripts played a key role. Sharing interest and achievements was also significantly predictive of being a girl. If the criterion was not met (i.e., sharing of interests was seen as typical) the participant was almost four times more likely to be a girl, with 38% of girls (and only 13% of boys) having no apparent impairment in their willingness to share their interests and achievements.

Nonverbal communicative behaviour. A key example of sex differences in overt behaviour presentation was found on the nonverbal behaviour category. Here,

preserved skills in the ability to integrate nonverbal and verbal gestures was significantly predictive of being female. From predicted odds ratios if a child presented at the diagnostic assessment with no abnormality in nonverbal communication abilities they were four times more likely to be a girl than boy. Over one-third of the girls (34.5%) in the sample were rated as having no impairment in their ability to integrate nonverbal and verbal communicative behaviours (compared to 9% of boys).

Interestingly, while girls presented with better use of social gestures, the ability to understand and interpret nonverbal behaviours was not predictive of sex. This was considered significantly impaired for 75% of girls and 89% of boys. Consequently, the sex difference in the behaviour presentation (i.e., the ability to use social gestures) was not reflective of the child's underlying understanding. No impairment in the child's ability to interpret others' nonverbal cues was evident for only 10% of girls and no boys.

Friendships and public appearance. Results on the breakdown of behaviours examined on the relationships domain also suggested girls reportedly present with better imagination (at least on face value) and a different manifestation of friendship issues (see Table 5.2). For imagination, being able to demonstrate typical imaginative play or some imaginative play were both predictive of being a girl, with 75% of girls falling in to these categories (45% with no impairment and 30% with some impairment). In contrast, only 18% of boys were rated as having no impairment in imagination, and a further 18% rated as having somewhat impaired imagination. If the child could engage in imaginative play considered typical for their developmental level, they were 3.5 times more likely to be a girl than a boy. If the child 'somewhat' demonstrated imaginative play they were 2.5 times more likely to be a girl than boy.

Here, the ‘somewhat’ category represents those children who demonstrated some imaginary play, however, it was potentially based on scripts.

Only nine children in the sample were thought to have no impairments in their ability to make friends. However, while both sexes had difficulties with friendships, these problems tended to manifest differently in boys and girls. Specifically, girls were more likely to be able to initiate friendships but then have trouble maintaining them (coded as ‘somewhat’). Fifty per cent of girls met this criterion compared to 31% of boys. This difficulty maintaining friendships primarily stemmed from the need for control over play. Consequently, if the child presented with the ability to initiate but not maintain friendships they were 3.5 times more likely to be a girl than a boy. In contrast, 65% of boys compared to 40% of girls had trouble both initiating and maintain friendships. This suggests a higher number of boys with ASD have more pervasive friendship problems, thus potentially making the impairment more salient.

Additionally, it has been hypothesised that ASD may be more difficult to identify in girls, in part, due to girls presenting as more quiet and introverted when in public (Attwood et al., 2006). Partial support was found for this, with girls reportedly better able to regulate their behaviour in different situations. While having no issue with adjusting behaviour for the situation meant the child was nine times more likely to be a girl, this was only the case for 18% of girls (compared to only 1 boy). Having some (albeit inconsistent) management of behaviour across situations meant the child was over six times more likely to be a girl than boy. In contrast, having substantial impairments in the ability to adjust behaviour across situations meant the child was almost twice as likely to be a boy. That said, this was reported as a significant concern for 60% of girls (compared to 95% of boys). Overall, girls were more likely to show some ability to manage their behaviour in public, including monitoring volume of

voice, and avoiding socially inappropriate comments or externalising behaviours (e.g., 'meltdowns'). However, based on parent report this was still an issue for majority of girls in the sample.

Evidence of Imitation for Social Gain

I hypothesised that a key reason girls are able to hide their underlying social impairment, and present with less impaired overt behaviours, is due to their superior social imitation skills. To explore this hypothesis I used logistic regression analysis, controlling for age, with sex as the outcome variable. Results of this regression are presented in Table 5.7. First, not being able to imitate was not significantly predictive of sex, with only 17% of the sample having no basic imitation ability, confirming the higher-cognitive ability of the sample. However, if the child could imitate, there was a significant sex difference between the ability and inability to use this for social gain. That is, if the child was able to generalise their imitation ability to a social context (e.g., mimicking behaviour, social scripts) they were over three times as likely to be a girl. In contrast, being able to imitate, but not generalising this to a social context, meant the child was over four times more likely to be a boy rather than girl.

Table 5.7

Results of Logistic Regressions for Imitation Ability as a Predictor of Sex

Criteria	Predicted Odds	*Wald*(*df*)	*p*	*ExpB* [95% CI]
Imitation (overall)*		23.60(2)	<.001	
Used for social gain*	<u>3.65</u>	6.30(1)	.01	4.10 [1.36, 12.36]
Simple imitation	4.76	3.87(1)	.05	0.24 [0.06, 1.00]
No imitation (constant)	1.12	0.03(1)	.87	0.89 [0.23, 3.42]

Note. Underlined predicted odds ratios represent those variable levels predictive of being a girl
* $p < .01$

Restricted, Repetitive Behaviour Domain

Besides evidence of girls being less likely to demonstrate fixated interests, differences were also apparent in the stereotyped use of objects. Specifically, girls were substantially less likely to present with stereotyped use of objects (i.e., lining up or sorting behaviour). Twenty-seven per cent of girls did not meet criterion for this impairment compared to 6% of boys. Twenty-two percent of girls and 31% of boys somewhat met criterion, meaning the behaviour was sometimes, but infrequently, present. If the child did not meet this criterion the predicted odds ratio showed they were over eight times more likely to be a girl than boy.

Types of restricted interests. Besides proposing differences in overt behaviour presentation on the social domain, it has also been suggested that girls would present with different restricted interests to boys (Attwood et al., 2006). These interests may then be more difficult to identify as a sign of ASD (or indeed as atypical). Preliminary support for this hypothesis was presented in Chapter 4. In the current logistic regression analyses (see Table 5.8) again showed evidence of significant differences in the type of interests shown by girls and boys, $Wald(4) = 18.81$, $p < .001$. Age was not controlled for in this analysis, but will be discussed later. Girls were most commonly rated as having restricted interests in the 'random' category (60% girls, 29% boys). Consequently, being rated as having a seemingly random restricted interest (e.g., rocks, stickers, pens) significantly predicted the child was a girl. The category to most strongly predict being a boy was fixations with screen time. Screen time fixations were predominantly obsessive gaming, however also included obsessions with iPads or other such screen technology. Thirty eight percent of boys reportedly showed obsessional interests in screens, compared to very few girls (9%). This result differs from findings presented in Chapter 4, where boys' restricted interests primarily revolved around

wheeled vehicles. While fixations with wheeled vehicles remained predictive of being a boy, this was the fixation of only 12% of boys (and 6% of girls). This may be the result of the inclusion of older children in the current sample. As such, I also examined the types of restricted interests displayed by younger (< 7 years old) and older (> 7 years old) boys and girls (see Figure 5.2). Results confirmed younger boys' interests did revolve around wheeled toys, while the largest percentage of older boys were fixated with screens (e.g., television, gaming). The largest percentage of girls' restricted interests remained in the category of 'seemingly random' regardless of age group.

Table 5.8

Results of Logistic Regression for Type of Restricted Interest Predicting Sex

Interest Type	Predicted Odds	*Wald*(1)	*p*	*ExpB* [95% CI]
Specific program/character	<u>1.20</u>	7.01	.01	6.43 [1.62, 25.49]
Seemingly random (e.g., animals, rocks)	<u>1.68</u>	14.02	<.001	8.42 [2.76, 25.69]
Wheeled vehicles (e.g., cars)	4.00	0.08	.78	1.25 [0.26, 6.12]
Toys (e.g., teddy-bear)	<u>1.33</u>	4.37	0.04	6.67 [1.13, 39.47]
Screens (e.g.,videogames)	5.00	10.79	.001	0.20 [0.06, 0.52]
constant				

Note. Underlined predicted odds represent those types predictive of being a girl.

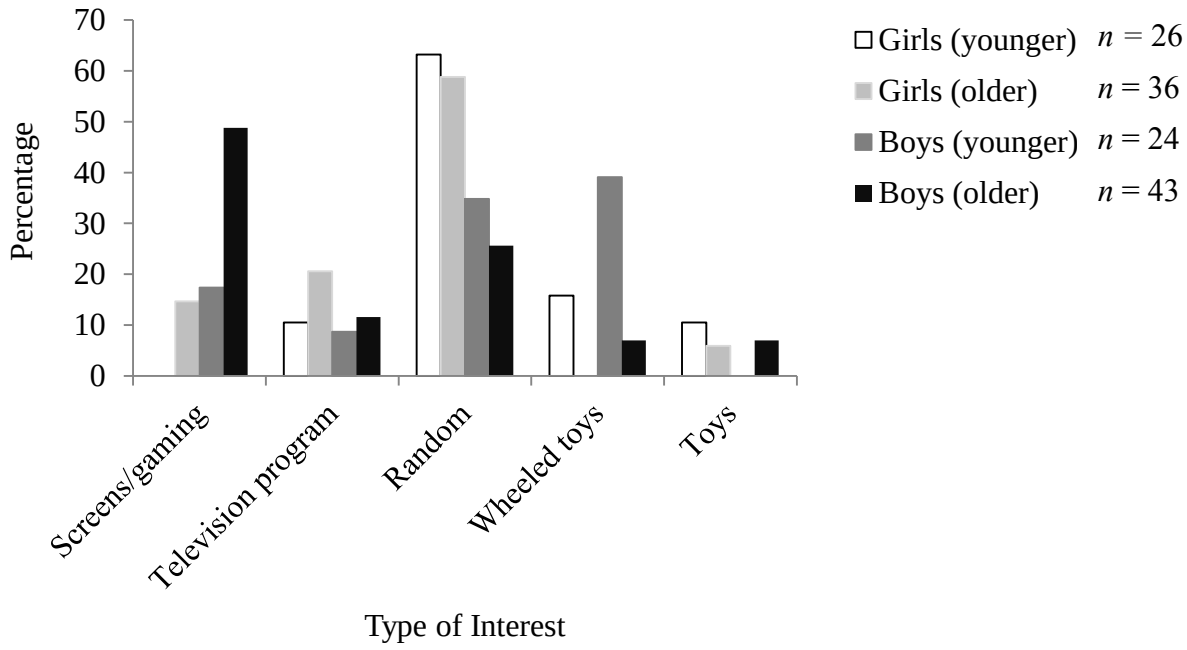

Figure 5.2. Percentage of younger (<7 years old) and older (>7 years old) boys and girls who displayed particular type of restricted interest

The Role of School Presentation

The final hypothesis in this study was that girls with ASD may present with less impairments when in the school environment. That is, based on previous research (e.g., Mandy et al., 2012), I hypothesised that, compared to boys, girls would present with fewer behaviour and social concerns in a school setting, meaning underlying impairments may be less salient. To test this, information on school presentation of boys and girls with ASD was collected from two sources (parent report on the pre-school years and school report on current functioning).

Parent report on the pre-school years. As part of the clinic's standard practice, parents reported on concerns that had been expressed to them during the child's pre-school years. Chi square analysis showed significant sex differences in early concerns, $\chi^2(4) = 26.75$, $p < .001$, $ø_c = .55$. The largest difference was in reporting that no teacher expressed concern during the pre-school years. This was reported for 47.6% of girls ($n = 20$) and only 11.1% of boys ($n = 5$). In contrast, 48.9% of parents of boys reported concern was expressed regarding the externalising behaviours of their son ($n = 22$), with this concern reported for only 9.5% of girls ($n = 4$). Remaining concerns were with general learning (girls: 11.9%, $n = 5$; boys: 4.4%, $n = 2$), social development (girls: 26.2%, $n = 11$; boys: 17.8%, $n = 8$), and specific querying of ASD (girls: 4.8%, $n = 2$; boys: 17.8%, $n = 8$).

Teacher reporting. Teacher-reported information was available for 43 boys and 40 girls.[20] Logistic regression analysis, controlling for age, showed significant differences were evident across a range of teacher concerns. Logistic regression results are presented in Table 5.9, with percentages of boys and girls for whom concern was

[20] There was no significant difference in the age ($p = .41$) or IQ ($p = .34$) for those children for whom teacher-report was available.

(and was not) expressed, presented in Table 5.10. Of note, significant concern with externalising behaviours was reported for 50% of boys and only 13% of girls. For 70% of girls, teachers reported no concern regarding externalising behaviours (compared to only 21% of boys). Across the majority of impairments, teachers reported significant concerns for far fewer girls than boys. Indeed, the only areas where no sex differences were evident (restricted interests and odd movements) were areas where teachers had fewer concerns for either sex, most likely because of difficulty identifying those behaviours in a classroom context. These results provide support for the idea that girls with ASD present at school with substantially fewer behaviour and general problems than boys, and that underlying impairments are thus likely less salient.

Table 5.9

Results of Logistic Regressions on Teacher-Rated Items Predicting Sex, After Controlling for Age

Category	Predicted Odds	*Wald*(*df*)	*p*	*ExpB* [95% CI]
Externalising*		18.64(2)	<.001	
No concern*	7.34	17.13(1)	<.001	14.68 [4.11, 52.37]
Somewhat	1.31	1.91(1)	.17	2.62 [0.67, 10.29]
Significant concern (constant)	2.00	0.78(1)	.37	0.50 [0.11, 2.33]
Social Skills*		18.86(2)	<.001	
No concern*	14.10	14.90(1)	<.001	26.60 [5.02, 140.66]
Somewhat*	3.01	9.64(1)	<.01	5.68 [1.90, 16.98]
Significant concern (constant)	1.19	0.68(1)	.41	0.53 [0.12, 2.36]
Friendships*		9.01(1)	.01	
No concern	10.96	5.53(1)	.02	5.35 [1.32, 21.63]
Some concern*	10.09	6.65(1)	.01	4.92 [1.47, 16.49]
No friends (constant)	2.05	0.82(1)	.37	2.05 [0.43, 9.68]
Conversation Skills		6.38(2)	.04	
No concern	2.83	5.76(1)	.02	4.64 [1.33, 16.24]
Somewhat	1.12	0.79(1)	.37	1.84 [0.48, 7.10]
Significant concern (constant)	1.64	0.32(1)	.57	0.61 [0.11, 3.32]
Routine dependence*		9.01(1)	.01	
No concern*	9.67	8.41(1)	.004	8.41 [1.99, 35.44]
Somewhat	4.03	3.15(1)	.08	3.50 [0.88, 13.93]
Significant concern (constant)	1.15	0.03(1)	.87	1.15 [0.24, 5.51]

Restricted Interest		0.15(2)	.93	
No concern	1.59	0.03(1)	.87	1.09 [0.37, 3.20]
Somewhat	1.99	0.15(1)	.70	1.36 [0.29, 6.30]
Significant concern (constant)	1.46	0.25(1)	.62	1.46 [0.34, 6.36]
Atypical Movement		2.60(2)	.27	
No concern	2.74	2.23(1)	.14	2.38 [0.76, 7.43]
Somewhat	1.03	0.02(1)	.90	0.84 [0.06, 11.16]
Significant concern (constant)	1.15	0.03(1)	.88	1.15 [0.22, 6.43]
Academic Performance		2.63(2)	.27	
Age appropriate	1.32	0.42(1)	.52	1.46 [0.46, 4.61]
Behind in specific class	1.73	2.58(1)	.11	3.32 [0.77, 14.37]
Behind across curriculum	1.92	0.59(1)	.44	0.52 [0.09, 2.74]

Note. Underlined predicted odds ratios represent those variable levels predictive of being a girl

*$p < .01$

Table 5.10

Percentage of Boys and Girls for whom Teachers Reported No, Some, or Significant Concern with Behaviour

Category	Girls % (*n*)	Boys % (*n*)
Externalising*		
No concern*	70.0 (28)	21.4 (9)
Somewhat	17.5 (7)	28.6 (12)
Significant concern	12.5 (5)	50.0 (21)
Social Skills*		
No concern*	37.5 (15)	4.7 (2)
Somewhat*	40.0 (16)	23.3 (10)
Significant concern	22.5 (9)	72.1 (31)
Friendships*		
No concern	27.0 (10)	11.4 (4)
Some concern*	40.5 (15)	22.9 (8)
No friends	32.4 (12)	65.7 (23)
Conversation Skills		
No concern	58.8 (20)	30.8 (12)
Somewhat	26.5 (9)	33.3 (13)
Significant concern	14.7 (5)	35.9 (14)
Routine dependence*		
No concern*	45.5 (15)	16.7 (5)
Somewhat	24.2 (8)	16.7 (5)
Significant concern	30.3 (10)	66.7 (20)
Restricted Interest		

No concern	46.9 (15)	48.5 (16)
Somewhat	15.6 (5)	12.1 (4)
Significant concern (constant)	37.5 (12)	39.4 (13)
Atypical Movement		
No concern	74.2 (23)	53.3 (16)
Somewhat	3.2 (1)	6.7 (2)
Significant concern (constant)	22.6 (7)	40.0 (12)
Academic Performance		
Age appropriate	48.4 (15)	51.4 (19)
Behind in specific class	29.0 (9)	13.5 (5)
Behind across curriculum	22.6 (7)	35.1 (13)

* $p \leq .01$ based on logistic regression models

DSM-IV-TR versus DSM-5

Given evidence that girls present with a variety of behaviour differences to boys, I was also interested in whether this would impact girls' ability to reach criteria on the DSM-5. Chi-square analysis showed no significant difference in the percentage of boys and girls who failed to meet criteria on the DSM-5 (after meeting criteria on DSM-IV-TR), $\chi^2(3) = 7.41$, $p = .06$, $ø_c = .26$. However, the effect size suggests this may be a power issue, with 31.4% of girls ($n = 16$) and 17.5% of boys ($n = 11$) failing to meet DSM-5 criteria. For all cases, the failure to meet DSM-5 criteria was due to failing to meet at least one of the 3 criteria on the social domain. For boys, this was spread across all three social categories. For girls who failed to meet DSM-5 criteria, 69% ($n = 11$) failed to fully meet criteria on the nonverbal communication domain (where I found overt behaviour differences yet no difference in underlying understanding). Failing to

meet criteria on DSM-5 was primarily an issue for those children with a diagnosis of PDD-NOS. Four out of eight girls (50%) and two out of six boys (33%) with an original PDD-NOS diagnosis failed to meet DSM-5 criteria. Eleven girls and nine boys had an original diagnosis of Asperger's disorder, while one girl had an original diagnosis of autistic disorder.

Discussion

The primary aim of this research was to investigate why ASD may be more difficult to detect in females, which may explain, in part, the large sex discrepancy in the diagnostic rates of ASD. In particular I was interested in how cognitively able girls with ASD may present differently to boys. Specifically, I focussed on sex differences in the behaviours within each diagnostic criterion, as outlined by the DSM-5. Differences in teacher reporting were also examined. There were four key findings that provided insight into why ASD may be more difficult to identify in girls. First, results showed substantial sex differences in many readily observable impairments, including nonverbal behaviours and conversation skills, despite significant underlying social impairment. Second, from the diagnostic reports, girls were more likely to use imitation as a strategy to manage social situations. Third, girls also presented with different types of obsessive behaviour that may be more difficult to identify as atypical. Finally, teachers expressed substantially fewer concerns for girls than for boys. Taken together, results suggest girls present with some key differences in their overt behaviours, likely making the behavioural presentation of the disorder different in girls. Girls' ability to hide potential social impairments also seems most pronounced when in the school environment.

Results showed no significant difference across the broad social criteria, for both DSM-IV-TR and DSM-5, supporting recent findings by Mandy, et al. (2012), who

engaged a similar sample. Evidence of no significant difference is perhaps unsurprising, given all children sampled had already met DSM-IV-TR criteria for ASD. What I was more interested in was whether sex difference would be evident in what specific behaviour impairments were (and were not) evident within each criteria. These were the behaviours proposed to create the 'look' of ASD, which may impact on a medical professional's judgement on whether an impairment is indeed ASD. Importantly, boys and girls reportedly suffered equally from a lack of social understanding (e.g., the ability to interpret nonverbal cues), however the overt behaviour impairments which may influence a decision to explore a potential ASD diagnosis manifested quite differently between the sexes. Examples included girls being better able to use nonverbal gestures and engage in reciprocal conversations.

Of note, for many behaviours (e.g., friendships, conversation skills, adjusting behaviour across situations) girls were more likely to fall in to the 'somewhat' category. As such, it was not that there was no impairment present, but that the behaviour was not as impaired as the clinician would expect for a 'typical' ASD impairment. Given the more ambiguous presentation of these impairments in girls, as evident in the reports of clinician's specifically trained in making ASD diagnoses, it is likely that identifying these behaviours as signs of ASD would be even more problematic when parents express concern to general practitioners, or other medical professionals, not specifically trained in the diagnosis of ASD.

Results also supported the finding that, compared to boys, fewer girls with ASD presented with restricted interests and fewer lining up or sorting behaviours (Hartley & Sikora, 2009; Mandy, et al., 2012). In conjunction with the above discussed differences in overt social presentation, fewer restricted interests also likely play a part in making ASD more difficult to identify in girls. A major contribution of this work is that it is the

exploration of the specific types of restricted interests displayed by boys and girls. For the 89% of boys and 58% of girls who did present with a fixated interest, my results showed girls and boys presented with quite different types of fixations. Specifically, compared to girls, boys were more likely to demonstrate fixated interests with televisions or video games, while girls were more likely to demonstrate collecting behaviour or interests around seemingly random objects. This included animals, rocks, shells, or reading books. Interestingly, when the sample was split in to older and younger children, these seemingly random fixations held by many girls, remained the most common category.

There are numerous reasons why this sex difference in the object of the child's obsessional interest, may make it more difficult to identify girls' restricted interests. The idiosyncrasy of the interests of girls may indicate that the behaviour is less likely to emerge as an obvious fixation and, therefore, as an indicator of ASD (especially to a non-expert diagnostician). Further, these more random obsessions are potentially more difficult to identify as atypical (or as a sign of ASD), particularly when the girl is younger. Alternatively, it may be that these interests are less impairing on daytime functioning of the child (and their family) than boys obsessions with gaming. Consequently, while the sex ratio in the presence of restricted interests may, in part, reflect biological differences (Szatmari, et al., 2012), my results suggest that at least part of this difference may be due to the current under-identification of how restricted interests manifest in girls. However, it will now be necessary for future research to specifically explore how these differences in girls' interests impact a professional's ability to identify the potential sign of ASD. Moreover, it would be useful for future research to explore whether sex differences in the interests of children with ASD may also be reflected in sex differences in the interests of typically-developing children.

Comparing differences in interests between sex and also typically- and atypically-developing samples would be useful to provide insight in to why restricted interests may be more difficult to identify in girls with ASD. For example, is it due to sex differences in the intensity of the interest? Alternatively, or additional, it may be because girls' interests are so similar to what would be expected in their typically-developing counterparts. Consequently, findings regarding sex differences in restricted interests, lead to numerous important areas for future research.

Outside the criteria comprising the DSM-5 diagnosis, I also examined the role of imitation. The camouflage hypothesis specifically posits that girls are better able to engage in camouflaging behaviours, such as mimicking, which may hide their underlying impairments (Attwood, et al., 2006; Kopp & Gillberg, 1992). As such, evidence was collected on references to boys and girls using imitation in a social context (e.g., relying on social scripts or mimicking during conversation and play). In support of the camouflage hypothesis, clinician report revealed that girls were far more likely to use imitation for social gain (i.e., to hide their underlying lack of social understanding). Specifically, girls were reportedly more likely to copy the social behaviours of siblings, parents, or peers. In contrast, if boys did engage in imitation, it was generally after prompting, and it was not used in a social context. This study, along with evidence chapter 4, was the first to show evidence of girls' greater ability to use imitation in a social context. This ability is potentially central to understanding why girls with ASD appear advantaged in their overt behavioural presentation, despite substantial impairments in their underlying understanding of social contexts. As such, this would be a worthy area for future investigation. In particular, it may be useful to directly examine the social imitation abilities of girls and boys with ASD, through observational assessments and direct testings, to provide a more robust understanding of

how and where they may engage in mimicking behaviour. Moreover, more direct testing of the imitation ability of boys and girls would provide important insight into the very nature of this mechanism. That is, are girls consciously engaging in imitation to 'hide' their impairments, or rather, are girls engaging in more implicit imitation? More specifically, are girls actively aware of their social difference and using strategies to explicitly hide their difficulties, or, are girls with ASD advantaged in their implicit imitation ability meaning they genuinely have better social abilities than one may expect of a boy with ASD. Either mechanism would make the presentation of the disorder less 'typical' and thus harder to identify in girls. The exact mechanism behind girls' ability to engage in mimicking behaviour remains a crucial question for further research to explore.

Teacher Reporting

This is only the second study to extensively examine differences in teacher reporting of girls and boys with ASD (see Mandy et al., 2012). Again, supporting results of Mandy et al. (2012) teachers reported substantially fewer concerns with girls' behaviour than with boys. In line with the camouflage hypothesis, relative to boys, girls were reported to more commonly present as introverted or demonstrated appropriate classroom behaviour. In contrast, for a high proportion of boys, externalising behaviours were a significant concern for teachers. This finding couples with evidence that boys were also more likely to have a previous ADHD diagnosis. Results add to evidence that boys with ASD present as more disruptive in a school environment, thus likely making impairments more salient to teachers. Further, teachers were also less likely to report concerns with girls' general social skills, conversation skills, and ability to deal with change in the classroom, compared to teachers of boys. While some of these sex differences were reflected in clinician reporting (e.g., girls being better able to

engage in reciprocal conversation), the difference was of a far greater magnitude in teacher report. For example, while 17% of girls were rated by clinicians as having seemingly typical conversation skills, 50% of girls were rated by teachers as having no concern with conversation skills. Some of these sex differences in school presentation may be, at least in part, due to girls engaging in mimicking and thus demonstrating fewer overt problems (e.g., nonverbal gestures, social scripts). However, reasons for how and why girls seem able to manage their behaviour when at school remains an important area for future research.

Strengths and Limitations

Data from this study was extracted from diagnostic assessments. A strength of this method is access to reports from a variety of sources (i.e., parents, clinicians and teachers), as well as access to a larger sample of cognitively-able girls with ASD. However, it is possible that some behaviours were not reported in the final report and available information, despite potentially being present. To minimise this issue, no mention of the particular behaviour was coded as missing data. As such, the behaviour was only coded if explicit reference was made to it either being present or absent. Also, I cannot rule out that reporting may have been affected by clinician expectations of what ASD should look like in girls (e.g., that they should camouflage). That said, reports were taken from extensively trained and experienced diagnostic clinicians, and included multiple sources of information (i.e., teacher, parent, clinician). Nevertheless, I would recommend that future research continues to explore the presence and absence of these behaviours (e.g., imitation, nonverbal skills) through direct observational or testing methods. In particular, it will be important for researchers to begin directly assessing the underlying social and cognitive impairments in girls versus boys with ASD. This will assist in determining whether differences in overt behaviours are present

despite girls and boys experiencing the same underlying impairments, or if girls are actually less impaired or present with a different variant of the disorder. Results of the studies presented in Chapters 4 and 5 suggest girls are equally as impaired as boys across many areas, including empathy (providing comfort) and understanding others nonverbal cues. However, more direct testing of these underlying processes remains an important area for future research.

Finally, I have argued that a particular challenge for girls with ASD may be their under-identification through the community diagnostic path, prior to the official diagnostic assessment. Specifically, I hypothesise that ASD may be less recognised when the parent presents with concerns to their general practitioner or family doctor, where resources may not be available to provide an extensive examination of underlying impairments, thus relying on behaviour presentation (where I have shown girls to be different). However, this is an avenue where further research is necessary, particularly to examine the role of medical professionals judgments of what ASD 'looks-like' and how it is identified as a potential diagnosis, long before the child undergoes a diagnostic assessment with a trained ASD diagnostician.

Summary

This study aimed to empirically investigate how ASD may present differently in girls versus boys. This is the first study to examine the specific components that comprise the broader diagnostic categories within the framework of both the DSM-5. Further, it is only the second study to extensively examine the role of school presentation on diagnostic rates.[21] Support was found in numerous areas for the hypothesis that girls may be able to hide, or camouflage, their symptoms. Consequently, they have provided insight into why ASD may be more difficult to identify in girls.

[21] Data collection for this study commenced prior to the publication of Mandy et al. (2012).

Importantly, evidence supports recent findings of no significant sex differences in the overall social criteria for ASD. However, I did find evidence of differences in the behaviour presentation of girls. They were more likely to engage in appropriate nonverbal behaviours and reciprocal conversation, despite significant impairment in the reciprocal understanding of social interactions. Results also suggested that girls present with less restricted interests than boys, however this may be due to under-reporting of restricted interests for girls due to difficulty identifying the interest as atypical. Finally, teachers reported far fewer concerns with girls' versus boys' school-presentation. Taken together, these results provide insight into why ASD may be harder to detect in girls. Consequently, this research may assist in beginning to form a framework for how clinician's and researcher's identify ASD in girls. Results have demonstrated the importance of both the understanding that girls with ASD are likely to present with fewer concerning behaviours in the school-environment, and that underlying impairments in social understanding may not manifest in behaviours considered typical of the male-centric presentation of ASD.

Chapter 6: General Discussion

Overview

In this thesis I explored potential reasons for why cognitively-able females are diagnosed with autism spectrum disorder (ASD) substantially less and later than males. This investigation was two-fold. First, I explored whether the sex differences in the diagnostic rates may represent a genuine prevalence difference, due to a female advantage in abilities related to social development. Second, I explored whether the diagnostic discrepancy may be the result of the under-identification of ASD in girls, and thus not a true prevalence difference. Here, I examined sex differences in the pre-diagnosis concerns for girls and boys later diagnosed with ASD, as well as sex differences in a large sample of girls and boys with ASD, based on clinician- and teacher-report. Overall, I found little evidence to support the first theory, with few robust differences in the cognitive and social profiles of typically-developing pre-school aged children. However, I did find evidence to support the second theory, with evidence that girls with ASD present differently to boys, which potentially makes the disorder more difficult to detect.

Compared to boys, girls were more likely to engage in behaviours that enabled them to camouflage their underlying impairments (e.g., mimicking). Girls also presented with less impaired nonverbal skills and fewer friendship problems, along with different types of restricted interests. Teachers also expressed far fewer concerns for the social skills and general behaviour of girls than of boys. Results suggest the disorder would be more difficult to detect in girls, particularly for those professionals not trained in the comprehensive diagnosis of ASD (e.g., family doctors). As such, while it is likely the diagnostic difference is partially explained by biological differences (Werling & Geschwind, 2013), based on the studies presented in this thesis, it would appear the

disorder is also potentially under-detected in girls. Consequently, the sex difference in the diagnostic rates may not represent a genuine prevalence difference in the development of ASD, at least of the current magnitude of up to ten boys to one girl. Findings that ASD may be under-detected in girls have important ramifications. Most notably, the under-detection or misdiagnosis of the disorder not only means missing the important window for early intervention, but also likely missing out on the social, emotional, or learning support they may require during later childhood and beyond. Findings from this thesis assist in developing our understanding of how the disorder presents in girls, thus providing a framework for how family doctors, teachers, and diagnosticians can better identify the disorder.

Little Evidence for Typically Developing Girls Having Better Cognitive and Social Abilities

The first theory explored in this thesis was whether girls may develop ASD less than boys due to an advantage in abilities associated with social development. Primarily, I was interested in whether a female advantage in theory of mind ability, a cognitive construct associated with social development, may mean girls are better protected from developing ASD. As a secondary interest, I also explored whether sex differences in executive function may be associated with a female advantage in both theory of mind and social competence. I found little evidence to support either hypothesis. There was no overall female advantage in pre-school girls' theory of mind ability, although there was evidence of a female advantage on two of the six tasks. The first, Knowledge Access, was the task said to precede false-belief development, based on the progress of the five-item theory of mind scale. This may reflect the task which was most developmentally sensitive to our age range, where many children were not at an age where one would expect false-belief ability to have emerged. However, the

enthusiasm for this sex difference explaining why girls would develop ASD less frequently was dampened by the lack of association between the theory of mind abilities measured and social ratings, provided by both parents and teachers. That is, Knowledge Access performance was not significantly associated with overall parent or teacher ratings of social competence, with passing the task only associated with lower teacher-rated aggression. Similarly, while girls also demonstrated better developed false belief ability (based on the Sally-Anne paradigm), passing this task was also not significantly associated with any social competence items. Finally, there was also a distinct lack of evidence of sex differences in executive function, including planning ability, inhibitory control, and working memory. Consequently, there was little evidence that either cognitive processes may play a protective role in preventing girls developing ASD as frequently as boys.

Although the lack of a female advantage in theory of mind in pre-schoolers is in contrast to findings of a female advantage in theory of mind during childhood, adolescence, and adulthood (Baron-Cohen, et al., 1997; Bosacki & Wilde Astington, 1999; Carlson, Mandell, & Williams, 2004), there are previous studies that have found no evidence of sex differences in theory of mind ability (Caputi, et al., 2012; Wellman & Liu, 2004). This includes studies that have used the five-item theory of mind scale with older children (Peterson, et al., 2005; Wellman & Liu, 2004). Further, in more methodologically sound papers (i.e., where attempts have been made to control for verbal ability), the female advantage has been only minor (Calero, et al., 2013; Charman, et al., 2002).

Further to little evidence of sex differences, there was also a distinct lack of associations between theory of mind abilities and social development. This included those abilities where a female advantage was evident (i.e., Knowledge Access and

Sally-Anne false belief). This was surprising, given the well documented links between these constructs (e.g., C. Hughes & Leekam, 2004; Watson, et al., 1999). One possible explanation for this is that social benefits of more advanced theory of mind may not manifest until later in the pre-school years. That is, the inclusion of children from toddlerhood may have meant the sample was too young to see any associated benefit of theory of mind. However an alternate explanation, as acknowledged in a review of theory of mind and social functioning, is that the importance of theory of mind for social development has been overstated (C. Hughes & Leekam, 2004). Social development is a complex process, with many factors influencing the rate and competency of children's social development. Given the potential extent of this complexity, findings may be sensitive to what specific aspects of social competence are measured and how they are measured (e.g., questionnaire, parent report, self-report, observation).

In the past, the ability to draw conclusions from the literature on the potential role of theory of mind development had been impaired by such issues such as the sole focus on false-belief as the measure of theory of mind, and the lack of well validated theory of mind measures. Indeed, the false belief task itself, previously used to assess sex differences (e.g., Charman, et al., 2002; Walker, 2005), has shown evidence of both strong (A. Hughes, et al., 2000) and poor (L. Mayes, et al., 1996) psychometric properties. In this thesis I presented evidence of the validity and usability of the five-item theory of mind scale with toddlers and pre-schoolers. I also ensured receptive vocabulary was controlled for across the entire sample. As such, with a validated tool, which measures a variety of theory of mind abilities, it may well be that there is no robust sex difference in theory of mind, meaning that this construct is unlikely to protect girls from developing ASD.

That said, I also acknowledge limitations in my study that may have impeded the ability to draw strong conclusions on both sex differences in theory of mind and its link to social competence and some outstanding questions about the use of the five-item scale. Most notably, the study engaged a relatively small sample. Further, the low return rate of the correctly completed parent report social measure (VABS-II) and the use of an unstandardized measure of teacher rated social competence may have impacted the ability to draw robust conclusions on the associations between theory of mind and social competence. Moreover, the lack of association between the theory of mind scale and social competence, bring in to question the validity of the scale. However, as previously discussed, this may be due to the poor sensitivity of the social measure used (an unstandardized scale) and the low return rate of the VABS-II. Consequently, further exploration of the association between the scale's five tasks and social competence is required.

Furthermore, while I found little evidence that typically-developing pre-school girls develop better cognitive and social skills than boys, I do not rule out that other areas, not explored in this thesis, may still protect typically-developing girls from developing ASD as frequently as boys. Future research may benefit from further exploring the role of theory of mind in a longitudinal framework, or focus on other areas related to development that may impact whether a girl does or does not develops ASD. Importantly, I also acknowledge that differences may exist for atypically-developing children, something which was not directly tested in this thesis. That is, sex differences in theory of mind and executive function may be evident in atypically-developing children, potentially impacting on the sex ratio for children diagnosed with ASD, as well as those in the sub-clinical range. This represents an important and

necessary step in determining whether sex differences in the diagnosis of ASD may be, in part, due to sex differences in underlying cognitive abilities.

Girls Are Exposed to More Socially Complex Environments

Evidence suggested that typically-developing girls were more frequently exposed to environments that may promote more complex social interactions. However, in a typically developing sample, this did not significantly affect social competence. First, girls both used, and were exposed to, more frequent use of mental state talk during parent-child interactions. When engaged in free-play with a parent, girls were more likely to use utterances pertaining to desires (e.g., 'want', 'need'). Further, girls were more likely to be exposed to utterances pertaining to other's or the self's cognitions (e.g., "I know"), as well as utterances that modulate certainty (e.g., 'maybe', 'might'). Desire utterances (used more by girls) are said to precede the development of cognitive, and then assertion, utterances (used more by parents of girls). Taumpoepeau and Ruffman's (2008) longitudinal analysis of mental state talk found parents use of this style of utterance significantly predicted children's later use of mental state talk. The study presented in this thesis was cross-sectional, meaning longitudinal conclusions cannot be drawn. However, findings from Taumpoepeau and Ruffman suggest parents more complex use of utterances with girls, may indeed lead to the girls themselves to use more mental state talk compared to boys.

More frequent use of mental state talk by children was associated with a stronger preference for engaging in role play style games (pretend play). From teacher ratings, this style of play was the preferable play style for substantially more girls than boys. Pretend play is said to provide a rich practice ground for children to learn and develop social rules (e.g., cooperation) and perspective taking (Lillard, 1993; Stagnitti & Unsworth, 2000). Consequently, it was hypothesised that girls' stronger preference

for pretend play, and more frequent use of, and expose to, mental state talk, may result in greater overall social competence. However, these associations were not found, meaning while girls were more readily exposed to more complex social environments, this exposure was not associated with greater general social competence.

The lack of association between these environments and social competence is perhaps not surprising given I used a typically-developing sample. As such, by definition, all children, regardless of sex and play style, were developing social competency at a typical rate. Indeed, children were rarely rated as having below average social skills on any social items (e.g., prosocial, aggression, friendships). As such, the lack of associations between environment and social competency may be the result of little variation in the social competence of these children. Further, given the complexity of social development, it is likely there are many other socially-rich environments, outside of mental state talk, which foster both boys' and girls' social development.

Regardless, as previously discussed, to provide further insight in to the role of these processes (i.e., mental state talk) it will be important for further research to explore differences in populations of children with ASD. Indeed, the conversation patterns between a parent and a child who will go on to be diagnosed with ASD, are likely very different to the interaction between a parent and typically-developing child. Perhaps, for example, parents of girls who go on to be diagnosed with ASD, provide their daughter with a richer practice ground for perspective taking, than parents of sons who go on to meet criteria for ASD. That is, it is possible that these environments may provide developmentally 'at-risk' girls with a richer exposure to socialising. Exposure to these environments may allow girls with ASD to learn how to better engage in social play, resulting in a less 'typical' autism presentation when interacting with peers,

particularly during the pre-school years. This hypothesis was supported in the final study of this thesis (Chapter 5), which showed, girls with ASD reportedly had better developed imagination than boys. However, as predicted, many of these girls relied on social scripts or mimicking to engage in this play, demonstrating they had learnt how to 'act out' the play scenarios, despite underlying social impairment. As such, while typically-developing girls' exposure to mental state talk did not necessarily promote better overall social competence, these environments may have potential implications for the social presentation of atypically developing girls. This theory will be discussed for the remainder of this discussion.

Support for the Theory that ASD is Under-Identified in Girls

The second theory of interest was whether girls develop ASD at a higher rate than that currently reflected in the diagnostic criteria, but that the disorder is somehow more difficult to identify in girls. One potential theory, for why the disorder is under-identified in girls, is the camouflage hypothesis (Attwood, et al., 2006; Kopp & Gillberg, 1992). At the cornerstone of the camouflage hypothesis was the prediction that girls with ASD would be better than boys at imitating the social interactions of others, thus camouflaging their true underlying social impairment. In Chapters 4 and 5 of this thesis, through parent and clinician report, I have provided the first empirical evidence for the superior social-imitation skills of girls with ASD. First, in the pre-diagnosis period, compared to boys, girls reportedly presented with superior imitation skills, with parents reporting that girls were more likely to engage in complex imitation and imitation games. Further, girls were also more likely than boys to engage in mimicking to actively manage their social environment. This included reporting of girls mimicking interactions they had previously seen between adults, or interactions between peers. Moving away from retrospective parent-reporting, these results were

also supported by clinician reporting on imitation ability, as presented in Chapter 5. Here, clinicians reported girls were more likely than boys to use imitation for social gain. More specifically, many girls reportedly presented with an ability to generalise their imitation ability to a social context, where they would copy interactions in an aim to fit in socially. This was further evidenced by clinician report on several aspects of social skills. For example, clinicians were more likely to make references to girls potentially engaging in learnt scripts or delayed echolalia to give the appearance of more typical social skills, including engaging in reciprocal conversation and imaginative play.

It is possible that this imitation ability is at the core of why girls present differently to boys. However, it will be important for future research to both replicate and extend on the findings presented in this thesis. I have relied on clinician and parent reporting on the imitation skills of girls and boys. This methodology allowed me to access a larger sample of girls with ASD. However, it cannot be ruled out that clinician report may have been influenced by how they thought girls with ASD 'should' look (Attwood, et al., 2006). That said, reports were taken from clinicians with vast experience in the diagnosis of PDDs, across the full spectrum of the disorder. However, it would be useful for future researchers to empirically assess sex differences in imitation abilities directly. This should avoid focussing simply on whether girls and boys can or cannot imitate, but rather whether they have the ability to generalise that imitation skill for use in a social context. Direct observational assessments may be one such method, to capture exactly when and how mimicking behaviour is used.

Social domain: Same underlying impairment manifests in different behaviours. I found no evidence of sex differences in the presentation of core social diagnostic criteria on either the DSM-IV-TR or DSM-5. However, how girls and boys

came to meet criteria for each social impairment did differ, providing evidence that the behavioural manifestation of social impairments in ASD does indeed differ for boys and girls.

Broad social criteria. It has been argued that one reason for the inconsistencies in findings on sex differences on the core social criteria for ASD may be because studies have spanned different DSM criteria (Mandy, et al., 2012). A strength of this thesis was that sex differences were explored across the diagnostic criteria provided by both the DSM-IV-TR and DSM-5. Across two classification systems I found no evidence that girls differed from boys regarding whether or not they met each social impairment criteria. These findings are consistent with a recent study by Mandy and colleagues (2012) who engaged a similar age range (children and adolescents) to that presented in Chapter 5. That is, Mandy and colleagues found no significant differences in the social abilities of girls and boys through observational assessments by trained diagnostic clinicians. While these results are in contrast to evidence of both more severe (Carter, et al., 2007), and less severe (Lai, et al., 2011) social impairment in females, these contradicting studies have tended to focus on different age ranges, far smaller samples, and included children with intellectual impairment (e.g., Andersson et al., 2013; Carter et al., 2007).

Differences in the overt behaviour presentation. Despite no sex differences on the broader social diagnostic criteria, there were numerous areas where girls' overt behaviours presented differently to boys. This included girls reportedly being more likely than boys to engage in imaginative play, have an ability to make friends, and engage in reciprocal conversation when at school. Consequently, results suggest that the same level of underlying impairment seemed to manifest in quite different overt behaviours for girls and boys. One such example was on the specific impairments

present for nonverbal communicative behaviours. Despite boys and girls being equally impaired in their ability to interpret nonverbal cues (e.g., read others' facial expressions), girls were far better at effectively integrating nonverbal and verbal behaviours. That is, despite girls not understanding social nonverbal cues, they were still able to engage in the use of nonverbal behaviours when conversing with others. These differences, along with evidence of girls engaging in more active social compensatory strategies (i.e., mimicking) suggest girls are able to camouflage their underlying impairments. However, a limitation of this research was that the underlying cognitive and social abilities of children with ASD were not directly tested. This remains an important area for future research. In particular, gaining a more thorough understanding of these abilities will assist in differentiating whether girls do indeed actively camouflage (i.e., consciously hide significant underlying impairments) or if, perhaps, girls present with a variant of ASD, with genuinely better developed cognitive or social understanding. As previously outlined, direct assessment will be particularly important to ascertain whether girls are consciously engaging in these more 'active' social strategies (i.e., imitating) or whether this is an implicit advantage that means either girls' underlying social impairment are more difficult to identify, or, if girls with ASD are actually less socially impaired.

The presence of some atypicality. While across many social behaviours girls were more likely than boys to fail to show any impairments, the large percentage of girls were consistently rated as 'somewhat impaired.' That is, some atypicality was noted. For example, girls were far more likely than boys to be rated as only somewhat impaired (rather than 'impaired') in their ability to make and maintain friends. Indeed half of the girls in the sample were rated as being able to make friends, but then have difficulty maintaining those friendships. In comparison, the majority of boys had

significant difficulty both initiating and maintaining friendships. Similarly, a large percentage of girls were rated as only somewhat impaired in their ability to maintain a reciprocal conversation, meaning they seemed able to maintain an adequate conversation, but the clinician suspected the girl may be reliant on social scripts. Again, in contrast, this was an area where the majority of boys had significant difficulties (e.g., would not even attempt to initiate a conversation). Meeting this 'somewhat impaired' category showed that the clinician identified that the behaviour was not typical, but the impairment did not seem to match the level of impairment typically seen or expected in an individual with ASD. As such, even trained and highly experienced diagnostic clinicians were reporting girls were presenting with a more ambiguous behavioural presentation. If trained diagnostic clinicians are experiencing these difficulties determining whether an impairment is indeed enough to warrant a diagnosis of ASD, one would imagine that the task would be even more difficult for professionals not formally trained in the diagnosis of the disorder.

Restricted repetitive behaviour domain. Differences in the presentation of boys and girls across this second DSM-5 diagnostic category, lent further evidence to why the disorder is harder to diagnose in girls. First, girls were less likely than boys to present with restricted or fixated interests. This finding supports previous evidence that this difference remains consistent across the pre-school years, childhood, and adolescents, and in samples of children with comorbid intellectual impairment (Hartley & Sikora, 2009; Lai, et al., 2011; Lord, et al., 1982; Mandy, et al., 2012). However, I have argued that this alone does not provide an adequate explanation for the lower identification rates of ASD in girls, as there are a number of other restricted/repetitive behaviour criteria that may be met for a positive ASD diagnosis. However, in conjunction with the previously discussed knowledge of differences in the overt social

behaviours of girls, the lack of obsessional interests likely further adds to the difficulty detecting whether concerns may represent signs of ASD.

A novel aspect of the research presented in this thesis was the exploration of the specific type of restricted interests most commonly manifested by boys and girls. The camouflage hypothesis posited girls presented with different restricted interests to boys, which would be more difficult for professionals to identify as atypical (e.g., Attwood et al., 2006). My research provided the first empirical investigation of this hypothesis and found support both in the pre-diagnosis period and in a sample of children and adolescents with a current diagnosis of ASD. Across both samples girls were more likely to demonstrate fixated interests around random objects. This included collecting seemingly random objects, such as glitter, stickers, or pencils. In the pre-school years, girls were reportedly also more likely than boys to show obsessional behaviour around their toys (e.g., collecting and lining up of teddy bears). In contrast to girls' restricted interests, pre-school aged boys were far more likely to demonstrate fixated interests in wheeled toys (e.g., lining up of toy cars, spinning the wheels). This finding was confirmed in the younger sample (< 7 years old) of those children diagnosed with ASD, with a large percentage of boys also showing fixations with wheeled toys. In later childhood and adolescence, boys were more likely to present with fixated interests around screens and technology. Here the primary obsession was computers and gaming.

These differences in restricted interests may very well be the result of the types of toys young girls versus boys have access to. Nevertheless, these findings potentially affect the diagnosis of girls in a number of ways. First, as predicted by the camouflage hypothesis, the restricted interest of girls (i.e., more random) may be more difficult for professionals to detect as atypical, or indeed as a sign of ASD. For example, a young girl's love of collecting stickers may be more difficult to identify as atypical, compared

to a young boy engaging in repeated non-functional use of a toy car. In particular, boys' lining up and wheel-spinning of cars, representing a non-functional use of the toy, is clinically often considered a stereotyped 'classic' sign of ASD. Consequently, a professional (or parent) may be quicker to identify the behaviour as a potential sign of ASD. Girls' obsessions may not become more salient until they get older, and the interest becomes more developmentally inappropriate. This is in line with findings that from early childhood to adolescence, girls' obsessional interests remain fixated around random objects such as stickers and pencils. Indeed, while it may be socially acceptable for a pre-school girl to collect glitter pens, this is likely to stand out as atypical in the teenage years, and certainly as quite different from the interests of peers. To further explore why these interests may be more difficult to detect in girls, it will be important for future research to explore whether evidence of sex differences in the restricted interests of girls and boys with ASD may be in line with differences in the interests of typically-developing girls and boys.

Another explanation may be that boys' obsessional interests are more disruptive to family life, meaning the parent is more likely to report the problem, or stress to the professional how obsessional the behaviour appears. For example, obsessional gaming may be more disruptive to the running of the family, from taking the computer from another sibling to not being able to turn off the game at the parent's request. In contrast, girls' obsessions with lining up their toys or collecting random objects may be less difficult for the parent to manage and thus not as salient as a problem. While this idea is yet to be examined in the framework of sex differences, it has long been proposed that restricted interests are considered more problematic to parents and other observers if considered less socially acceptable or more disruptive (Frith, 1991).

Evidence suggests that the lower rate of restricted interests in girls may be due to girls requiring a higher genetic threshold to develop the behaviour (Szatmari et al., 2012). However, my results suggest the lower prevalence of this impairment in girls may also be partially explained by differences in how restricted interests present in girls. I have provided the first empirical evidence for differences in the types of interests shown by girls and boys. However, further research is required to confirm the mechanisms behind why girls' obsessional interests may be more difficult to identify. Moreover, it would be beneficial for future research to explore sex differences in the main interests of typically-developing girls and boys. This would provide invaluable insight in to whether sex differences found in children with ASD are also reflected in typical sex differences. Further, I have hypothesised that girls' restricted interests would be more difficult to identify as atypical. However, this remains an important area for future research. That is, it will be important for future research to empirically investigate whether professionals, particularly those untrained in autism diagnoses, do indeed have more difficulty identifying restricted interests presented by girls, compared to boys.

Girls' Impairments Less Identifiable in a School Context

Finally, it has been suggested that girls would also present with less impairments in a school environment, further compounding the difficulty identifying the disorder in girls (Attwood et al., 2006; Mandy et al., 2012). Across both Chapters 4 and 5 I found evidence to further support this claim. That is, teachers of girls with ASD were far less likely to express concerns for development or behaviour, compared to teachers of boys. In Chapter 4 I found a quarter of the girls in the sample reportedly had no teacher ever report concerns for the child's development or behaviour. In contrast, this was rarely the case for boys. I built on this finding in Chapter 5, where I collected information on both

parent- and teacher-perspective on the school presentation of boys and girls. Results confirmed that teachers were far less likely to express concern with the behaviour or development of girls. A parent of a girl may be concerned with her development, however if a teacher notes no concerns with socialising at school, it seems unlikely the parent or a professional would think difficulties may be a sign of ASD.

These findings represent only the second comprehensive exploration of sex differences in the school presentation of children with ASD (Mandy, et al., 2012). Both my research and that of Mandy and colleagues (2012) found that girls were far less likely than boys to reportedly demonstrate disruptive behaviour in the classroom or yard (e.g., violence, yelling). Indeed the majority of girls in my sample (70%) had a teacher report no concerns with externalising or disruptive behaviour. Girls presenting with fewer disruptive behaviour in a school environment may mean underlying problems are far less salient. Consequently, teachers may be less likely to report concerns to parents. In turn, this may again reduce the likelihood of parents seeking professional help for their concern.

Teachers of girls were also far less likely to report concerns with socialising, friendships, conversational skills, and routine adherence. As such, in a school setting, girls fail to present with many key signs of ASD. Indeed, the only behaviours where teachers did not express fewer concerns for girls (restricted interests, atypical movement), were those behaviours where teachers acknowledged they had difficulty identifying the behaviour, regardless of sex. Most notably, based on teacher report, girls with ASD presented with quite typical social skills when at school. Indeed, from Chapter 5, teachers reported no concern for the social skills of 40% of the girls (compared to 5% of boys) and no concerns in the reciprocal conversation skills of 60% of girls (compared to 30% of boys). However, there were some instances where

teachers, like clinicians, identified some atypicality in the girl's behaviour, but failed to note significant concern. For example, 40% of girls were rated by teachers as having some friendships problems. This meant the teacher reported the girl was able to make friendships but that there was often some conflict in the friendship group, or friendships were frequently changed. This reflected similar findings from clinician report. To a professional trained in the diagnosis of ASD, the inability to maintain friendships would potentially present as a sign of ASD. However, in the absence of general concern with social skills, and at least having the ability to make friends, it seems unlikely that a teacher would identify the friendship disruptions as a potential sign of ASD. In contrast, for the majority of boys, teachers reported more robust friendship problems, in that they were unable to make or maintain friends. This presentation is potentially more in line with the 'classic' look of ASD, particularly on the social impairment domain.

Importantly, teacher report was frequently in contrast to clinician or parent report. For example, during the pre-diagnosis period, I found significantly more parents of daughters, compared to parents of sons, reported their primary concern for their child's social development was their externalising behaviour (e.g., aggression). Further, in chapter 5, clinicians reported the majority of parents held significant concern for their daughter's behaviour management (although this was higher for boys). Similar results were also found by Mandy and colleagues (2012), where parents of girls reported more concern for their child's emotional symptoms compared to parents of boys. However, again, this concern was not reflected in teacher report (Mandy et al., 2012). One would presume it would be more difficult to diagnose the disorder when teachers are reporting girls present with quite typical social skills, or at least skills that are not significantly impaired at a rate of what a teacher may expect a child with ASD to present.

The role of differing school presentation for girls versus boys with ASD certainly warrants further research. Despite parents voicing significant concerns over their daughter's behaviour in the home environment, clearly these behaviour problems are then not manifesting in a school setting. First, it would be useful for researchers to investigate potential mechanisms behind why girls seem to be able to better manage their behaviour in a classroom setting, especially given this behaviour management ability appears quite unique to school. Second, observational assessments may prove a useful avenue to determine if the impairments are truly not present for girls at school, or whether teachers are potentially not noticing the behaviour. Finally, it would be useful for research to empirically investigate teacher's beliefs around what ASD 'looks-like' in a school setting. Understanding how teachers currently view ASD, and how it does or does not match the clinical manifestation of the full spectrum of the disorder, would go far in working towards educating teachers and other professionals on exactly how ASD may present differently in girls.

Summary: Moving Towards the Better Identification of ASD in Girls

In this thesis I explored potential reasons for why ASD is diagnosed both less and later in cognitively able girls. Two theories were investigated: (1) that girls are protected from developing ASD as frequently as boys due to better developed cognitive and social skills, and (2) that ASD is actually being missed in girls due to differences in overt behaviours, that make the underlying impairments more difficult to identify. Limited support was found for the first theory, although the importance of future research in this area was highlighted. However, robust evidence was found for the second theory. Differences between the sexes were found across both the social domain and the restricted/repetitive behaviours domain, all providing insight in to why ASD would be more difficult to detect in girls. In particular, I found that boys and girls

shared some common underlying social impairments, but that this manifested in quite different overt behaviours. Moreover, girls seemed to have the ability to regulate their behaviour when at school, with stark differences in teacher versus parent report, on the behaviour of girls. Finally, many key behaviour impairments presented in a more ambiguous manner in girls, with even trained diagnosticians having difficulty determining if an impairment was severe enough to be considered a sign of ASD.

Differences in girls' overt presentation across both diagnostic domains, as well as their ability to manage their behaviour in a school environment, all likely contribute to the difficult identifying ASD in girls. This may result in the problem being completely missed, or in the misdiagnosis of another disorder. Findings suggest that the diagnosis of ASD in girls requires the exploration of their underlying understanding of socialising. For example, are they able to read and understand social cues? Certainly, relying on overt observable behaviours, such as nonverbal gestures, may result in the diagnosis being missed or misdiagnosed. My results also suggest that the absence of concern from teachers, even regarding social development, does not exclude a diagnosis of ASD in girls. However, reports of an inability to maintain meaningful friendships may be a sign that a diagnosis of ASD should be investigated.

These results also have implications for the diagnosis of girls on the newly released DSM-5 criteria. There has been some concern in the literature that the new DSM-5 would miss the diagnosis of cognitively able individual's, such as those originally diagnosed with Asperger's Disorder or PDD-NOS (S. Mayes, Black, & Tierney, 2013; R. L. Young & Rodi, 2013). Given I have shown evidence of cognitively able girls presenting with more ambiguous overt behaviours, there is further concern that the DSM-5, and its more rigid criteria for meeting all three social deficits, may impede the ability to diagnose girls. My results suggest some concern may be

warranted, with almost one-third of girls diagnosed on DSM-IV-TR failing to meet criteria for DSM-5, all due to failing to meet all three social criteria. That said, a positive of the DSM-5 is the acknowledgement that girls with ASD may present differently to boys. As research continues to develop a better understanding of what these differences may be, it is likely the identification of girls will improve, regardless of changes to the diagnostic criteria. The research presented in this thesis has provided insight in to what some of these differences may be, particularly in terms of the overt behaviour presentations of cognitively-able girls with ASD. It remains a challenge to researchers to continue to investigate how ASD may present differently in girls, and to disseminate this research in a timely manner to those professionals who are tasked with determining whether behavioural and developmental concerns may be a sign of ASD.

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Appendix A

Theory of Mind Scripts

Diverse Desires

[Display doll and pictures of a carrot and biscuit]: Here is a girl. The girl wants her morning tea. Here are two foods, a carrot and a biscuit.

Pretest Question: Which do you like best? That's a good choice! But the girl doesn't like [their choice]. She likes [opposite]. She loves to eat [opposite] best of all.

Test Question: So now the girl can choose only one food. Which will she choose? [Answer: Opposite to what the child chose].

Diverse Beliefs

[Display doll and pictures of bushes and garage]: This man wants his cat. The cat is hiding. It could be in the bushes or it could be in the garage.

Pretest Question: Where do you think the cat is? Well, that's a good idea. But the man thinks his cat is in [opposite].

Test Question: Where will the man look for his cat? [Answer: Opposite to where child chose]

Knowledge Access

[Display toy chest with drawer closed]: Here is a drawer.

Pretest Question 1: What do you think is in it? [The child can give any answer to indicate that they are not sure]. That's a good guess. Let's open it. Oh, look! There is a dog in! [Display dog then close drawer]

Control Question 1: So what is in the drawer? [Answer: Dog]. [Doll enters]: This girl has never seen this drawer before. She has never opened it.

Control Question 2: So has she looked in this drawer? [Answer: No]

Test Question: Does the girl know what is in this drawer? [Answer: No]

False Belief

[Display closed Band-aid box]: Here is a Band-Aid box. What do you think is in it? [If not answered 'Band-Aids', tester prompts with 'what is usually in a box like this?'] Let's open the box. Oh! There is a pig in it! [Tester closes pig in box]

Control Question 1: Okay, so what is in the box? [Answer: Pig]. [Doll arrives]. Here comes a girl. She has never looked in this box.

Test Question: What does the girl think is in the box? [Answer: Band-Aids]

Control Question 2: Did she look in the box? [Answer: No]

Hidden Emotion

Here is a boy [picture of back of boy's head]. The boy and his friends were playing. A girl teased the boy and the others all laughed. The boy did not laugh. He did not think it was funny. But the boy did not want the others to see how he felt. If they saw how he felt, they would call him a baby.

Real Emotion Question: How did the boy really and truly feel when everyone laughed and teased him? [Present with picture of happy/ok/sad faces]. [Answer: Sad]

Apparent Emotion Question: How did the boy try to look on his face when everyone laughed and teased him? [Answer: Ok/Happy]

Appearance Justification Control Question: Why did he try to look [sad/happy/ok]. [Answer: Any response that shows understanding of the story].

Sally-Anne False-Belief

This task (not from the five-item scale) is based on the traditional Sally-Anne theory of mind task. Two distinct containers are placed on the table in from of the child. The child is then given a green ball to hold. A puppet ('Sally') appears and the child is told that the ball belongs to the puppet and that she is going to play with his friend. A second puppet ('Anne') then arrives and the two puppets throw the ball back and forth between them. Sally then takes the ball and places it in the red box and leaves the scene. Anne then opens the red box, takes the ball, moves it to the blue box, and leaves. Sally then returns to the scene. The following questions are then posed:

Test question: Where does Sally think the ball is?

Control question: Where is the ball <u>really</u>?

Appendix B

Executive Function Tasks

Spin the Pot

This multi-location search task, based on that used by Hughes and Ensor (2007) is introduced to children as a fun game "where you can win lots of stickers." Eight distinct jars (i.e., various colours, textures, and sizes) are placed on a lazy-susan (spinning surface). The child is made aware that they will be asked to find stickers that are placed in the jars. The child (with the examiners assistance) then hides six stickers in six of the eight jars, and all lids are replaced. The jars are then covered with a scarf and the examiner spins the lazy-susan. The scarf is then removed and the child is instructed to choose one jar that they think has a sticker inside. If a sticker is found the child is able to retrieve the sticker, offered praise, and the jar-lid replaced. If a sticker is not found the lid is replaced and the next trial begins. Once the child has made the choice (regardless of whether it was correct or incorrect) the scarf is replaced and the table spun again. This continues until all six stickers are found or for a maximum of 16 trials. The total number of errors are recorded.

Wrapped Gift

This task, measuring inhibitory control, was based on a similar gift delay task used by Carlson, et al. (2005). It begins with the examiner presenting the child with a box, wrapping paper and sticky tape, and informing the child that they have a present to wrap. The child is then instructed that they are not allowed to look while the present in being wrapped, and must turn around until the examiner instructs them that it is time to look. The examiner then spends 1 minute noisily wrapping the present. The child is

scored on a scale of 1 (turns around) to 5 (does not peek), with the time until first peek recorded. For example if the child peeked over their shoulder at 20 s they would score a 3. If the child did not peek they would score a 5, and the time recorded would be 60 s. The examiner then asks the child if they think the present would look better with a ribbon on it. The examiner then reveals that they have a ribbon that they have left in the next room. The child is asked if they could wait with the present while the examiner retrieves the ribbon. The child is clearly instructed that they must not touch the present. The examiner then leaves the room for two minutes. In Carlson and colleagues (2005) study this was a three minute wait, however, piloting showed that three minutes was too long for majority of the children and they would simple leave the table and go on playing something else. For this waiting period the child is scored on a scale of 1 (opens gift) to 3 (does not touch gift). The time until the gift is first touched is also recorded, meaning that if the child refrained from touching the gift the time given was 120 s. Once the ribbon has been attached the child is able to help decorate the present with stickers and stamps.

Tower of Hanoi

This task, measuring planning ability, was also based on that used by Carlson, et al., (2004). The Tower of Hanoi apparatus is a wooden game with three pegs attached to a rectangular board. On each of the three pegs is a circular wooden disc that the child must move around according to set patterns and instructions. The child was instructed that this task was a ‘monkey jumping game’. The following story was then told:

> [Blue scarf placed on the table]. “For this game, we are going to pretend that the scarf is a big blue river. [Tower of Hanoi task placed on scarf]. And on this river there are three trees. Can you point to the

trees? [child points the three trees, assisted if required]. Sitting on our trees are three monkeys! There is a big daddy monkey, a medium mummy monkey, and a little baby monkey [point to largest disk, medium disk, and small disk, respectively]. The monkeys love jumping from tree to tree to visit each other [demonstrate the 'monkey' jumping]. But only one monkey can jump at a time. Also, the monkeys have to stay on a tree or they will fall in the river. Also the bigger monkeys cannot sit on the smaller monkeys [demonstrate] or the small monkey will get squashed. So only the smaller monkeys are allowed to sit on the bigger monkeys. [Present second Tower of Hanoi]. Look! I have my own monkeys on the other side of the river. Can you point to my three trees? [prompt if needed]. Here is my daddy monkey, here is my mummy monkey, and here is my baby monkey. Our monkeys like to copy each other so they look the same! So if my baby monkey jumps, your baby monkey will jump! [show example]. Let's see if we copy!

The examiners 'monkeys' are then moved in various patters out of sight of the child. The task is then put back on the table and the child instructed to 'try and make your monkeys look the same as my monkeys', whilst also being reminded of the three rules. Sixteen patterns were administered in total, with the game discontinued after four consecutive errors. The first four trials required a one-step move (i.e., only one disc required moving), trials 5-8 were two-step moves, trials 9-12 were 3-step moves, and trials 12-16 were four-step moves. An error was considered if the child broke a rule (i.e., large disk on small disk, moving more than one disc at a time, not keeping the disc on the peg).

A-not-B

A-not-B, used by Espy et al. (1999b), involves the child being presented with a wooden board with two identical red cups upside down on the board. The child is instructed that they are going to play a hiding game to try and win some more stickers. The sticker is then hidden under one cup, in sight of the child. The board is then removed from the table for 10 s, with the examiner and child counting in an animated voice during this time. The board is then returned to the table and the child instructed to "find the sticker/reward." Once the child has achieved two consecutive correct trials the reward is moved to the alternate cup. Thus, the reward is shifted based on performance. Based on the study by Espy et al., it was determined that 10 trials was sufficient to elicit enough variability in performance. The total number of errors was calculated.

Delayed A-not-B

This task, also used by Espy et al. (1999) is similar to A-not-B, in that the position of the reward is reliant on the participant's performance. Again the test board is placed on the table with the two identical red cups. Again the child is instructed that they are going to play a hiding game to try and find the sticker or reward. The key difference for this game is that the child does not see where the reward is hidden. They are either asked to shut their eyes or turn their back to the examiner (if they were unable to shut their eyes without peeking). Once the child correctly finds the reward, the next reward it is then placed under the alternate cup. If the child does not chose the cup with the reward, the reward stays under that cup until it is found. This task went for 20 trials and the total number of errors was calculated.

Appendix C

Teacher-Rated Social Competence Questionnaire

Please answer each question to the best of your knowledge, by circling the appropriate answer (please avoid ticking half-way between answers), in relation to how the child compared to their same-aged peers. All answers are strictly confidential and are not discussed with parents.

Child's name:

Age of child:

1. How would you rate this child's **dominance** during play? (Dominance over play is defined as a child who is constantly taking control in games, initiating the rules or roles during play, demonstrating high confidence, wanting to be the centre of attention during play, etc.)

   Never Present Occasionally Present Often Present Always

2. How would you rate this child's use of **aggression** during play? (Aggression includes any physical aggression, such as biting, pulling, hitting, kicking, and throwing an object at another child. It also includes verbal aggression, such as name calling, bullying, etc).

   Never Present Occasionally Present Often Present Always

3. How would you rate this child's ability to express **emotions appropriately** during play and leisure time? (Appropriately expressing emotion includes: showing the same levels of emotion as other children around them; responding appropriately to other people's actions, such as if another child is upset; being able to use words to express how they are feeling, such as happy, sad, or angry, etc. It could also be judged on their emotional maturity in comparison to their peers).

   Never Present Occasionally Present Often Present Always

4. How would you rate this child's use of **prosocial behaviour**? (Prosocial behaviour includes being helpful to other teachers and children, being kind to others, playing well and cooperating, etc).

Never Present **Occasionally Present** **Often Present** **Always**

5. How would you rate this child's **popularity** with his/her peers?

Very few or no friends **Few friends** **Group of friends** **Many Friends**

6. How would you rate this child's interest in **forming and maintaining friendships**?

Below Average **Average** **Above Average** **Extremely Good**

7. In your opinion, how would you rate this child's **overall social ability**?

Below average **Average** **Above Average** **Extremely Good**

8. In your opinion what is the main **style of play** that this child engages in (please choose only one)?

   a. Conversational pretend play (e.g., Game revolves around some kind of verbal interaction, usually in the form of role playing)
   b. Non-conversational pretend play (e.g., building train tracks and pushing trains around, 'cooking' with no or little conversation, etc)
   c. Physical play (e.g., running, climbing, slippery dip, throwing ball, etc)
   d. Solitary play (very little or no interaction)
   e. Other _____

Appendix D

Table D1

Results of Partial Correlations r (*p*)*, Controlling for Age, Between Performance of Executive Function (EF) Tasks and Individual Theory of Mind (ToM) Performance*

	Executive Function Tasks					
Theory of Mind Tasks	Spin the Pot	Wrapped Gift (wrap)	Wrapped Gift (wait)	Tower of Hanoi	A-not-B	Delayed A-not-B
Diverse Desire	.19 (.22)	.04 (.81)	-.26 (.10)	-.12 (.45)	-.16 (.30)	-.11 (.50)
Diverse Belief	.22 (.17)	.09 (.56)	-.01(.96)	-.20 (.20)	.10 (.16)	-.28 (.07)
Knowledge Access	-.26 (.09)	.25 (.10)	-.14 (.39)	-.23 (.14)	-.22 (.15)	-.28 (.07)
False-Belief	.10 (.53)	.04 (.79)	-.03 (.86)	-.30 (.06)	-.14 (.36)	-.21 (.16)
Hidden Emotion	-.01 (.94)	-.003 (.99)	.27 (.08)	-.31 (.05)	-.18 (.26)	.30 (.05)
Sally-Anne	-.03 (.86)	.30 (.05)	.02 (.91)	-.11 (.49)	-.02 (.91)	-.02 (.90)

Note. Spin the Pot, Tower of Hanoi, and A-not-B tasks coded as number of errors. As such, positive correlations mean poorer EF performance was associated with better ToM performance. Wrapped Gift tasks coded such that higher score represents better EF (inhibitory control) ability. As such, negative correlation mean better EF ability associated with worse ToM ability.

Appendix E

Table E1

Bootstrapping Results for Knowledge Access Performance Mediating an Indirect Association Between Sex and Social Competence

Social Rating	*B*	SE_B	Bootstrapping 95%CI
Parent			
Total	.08	1.40	[-2.60, 3.36]
Relating to Others	.13	0.38	[-0.38, 1.33]
Play and Leisure	.09	0.26	[-0.22, 1.00]
Adapting	-.05	0.30	[-0.85, 0.43]
Teacher			
Total	.03	0.07	[-0.11, 0.20]
Dominance	-.03	0.08	[-0.21, 0.10]
Aggression*	-.22	0.10	[-0.48, -0.07]
Emotion	.07	0.08	[-0.05, 0.31]
Prosocial*	.14	0.08	[0.03, 0.35]
Popularity	-.06	0.08	[-0.24, 0.07]
Maintenance of friendships	-.02	0.09	[-0.23, 0.16]

Note. CI = confidence interval

* Evidence of indirect mediation, as zero not crossed in the CI

Table E2

Bootstrapping Results for Sally-Anne False Belief Performance Mediating an Indirect Association Between Sex and Social Competence

Social Rating	*B*	SE_B	Bootstrapping 95%CI
Parent			
Total	.11	0.77	[-1.99, 1.21]
Relating to Others	.00	0.20	[-0.96, 0.18]
Play and Leisure	-.01	0.18	[-0.53, 0.28]
Adapting	.04	0.15	[-0.17, 0.45]
Teacher			
Total	-.01	0.05	[-0.12, 0.08]
Dominance	.04	0.06	[-0.02, 0.22]
Aggression	-.05	0.05	[-0.21, 0.01]
Emotion	.08	0.07	[-0.01, 0.28]
Prosocial	.08	0.06	[-0.01, 0.26]
Popularity	-.01	0.04	[-0.13, 0.08]
Maintenance of friendships	-.03	0.06	[-0.21, 0.05]

Note. CI = confidence interval

Appendix F

Pre-Diagnosis Concerns Questionnaire

Information Sheet

Hello. Thank you for volunteering to participate in this questionnaire study. Below is some information regarding the nature of the research. Before beginning the survey please ensure you are eligible to be involved. That is, your child has a current diagnosis of either high-functioning Autistic Disorder, Asperger's, or Pervasive Developmental Disorder Not-Otherwise-Specified AND was diagnosed at or after the age of five years.

This project involves the exploration of parent's early concerns for their child's development. This project aims to further our knowledge of factors that lead to the later diagnosis of children. We are particularly interested in how this may differ for boys and girls. For the purpose of this research project 'late-diagnosed' includes any child who was diagnosed at or after the age of 6 years. For the purpose of this research 'high-functioning' is defined as the child having some verbal ability with no intellectual disability. If you are unsure whether your child meets this criteria please contact the researcher on the details provided at the end of this letter.

The questionnaire that you will be presented with takes approximately 15 to 20 minutes to complete. Much of the questionnaire requires responding by marking the appropriate response box, while some questions require short responses.

As a thank you for taking time to complete this questionnaire you will receive a $15 Coles/Myer voucher.

Please note that you are able to withdraw from the questionnaire at any point by simply exiting the program. There are no consequences for withdrawing from the questionnaire.

This research will be used for the production of a PhD thesis and other publications. Be assured that no participant will be individually identifiable in the resulting thesis, report or other publications.

If you have any questions please do not hesitate to contact the primary researcher, Rachel Hiller, before commencing the questionnaire (ph. 8201 2370, email. rachel.hiller@flinders.edu.au).

This research project has been approved by the Flinders University Social and Behavioural Research Ethics Committee (Project 5665). For more information regarding ethical approval of the project the Executive Officer of the Committee can be contacted by telephone on
8201 3116, by fax on 8201 2035 or by email human.researchethics@flinders.edu.au.

I have read the information sheet/letter of introduction and wish to participate in the questionnaire:

If yes, simply press continue/next

If no, simply exit the program

Thank you

1.
The following question refers to your estimate of your child's current social and communicative functioning. Please select the level that most closely fits your child:

Level 1: (Minimal support) 'Requiring Support': Without supports in place, deficits in social communication cause noticeable impairments. Has difficulty initiating social interactions and demonstrates clear examples of atypical or unsuccessful responses to social overtures of others. May appear to have decreased interest in social interactions.

Level 2: (Moderate support) ' Requiring Substantial Support': Marked deficits in verbal and nonverbal social communication skills; social impairments apparent even with supports in place; limited initiation of social interactions and reduced or abnormal response to social overtures from others.

Level 3: (Considerable support) 'Requiring Very Substantial Support': Severe deficits in verbal and nonverbal social communication skills cause severe impairments in functioning; very limited initiation of social interactions and minimal response to social overtures from others.

2.
This question refers to your child's functioning regarding their repetitive/ritualistic behaviours. Please select the level that most closely fits your child:

Level 1: (Minimal issue) 'Requiring Support': Rituals and repetitive behaviours (RRB's) cause significant interference with functioning in one or more contexts. Resists attempts by others to interrupt RRB's or to be redirected from fixated interests.

Level 2: (Moderate issue) 'Requiring Substantial Support': RRB's and/or preoccupations or fixated interests appear frequently enough to be obvious to the casual observer and interfere with functioning in a variety of contexts. Distress or frustration is apparent when RRB's are interrupted; difficult to redirect from fixated interests.

Level 3: (Considerable issue) 'Requiring Very Substantial Support': Preoccupations, fixated rituals and/or repetitive behaviours markedly interfere with functioning in all spheres. Marked distress when rituals or routines are interrupted; very difficult to redirect from fixated interest or returns to it quickly.

3. Current age of child:

Gender: ☐male ☐ female

4. Your relationship to child:

☐ Mother

☐ Father

☐ Carer

Other (please specify)

5. What type of school does your child attend?

☐ Mainstream school

☐ Special (disability-specific) school

☐ Mainstream school but in a special education classroom

6. What is your child's current diagnosis?

☐ High-functioning Autistic Disorder

☐ Asperger's Disorder

☐ Pervasive Developmental Disorder Not Otherwise Specified

7. At what age was your child first given this diagnosis?

8. Prior to this diagnosis were any other diagnoses queried? Please specify.

9. At what age were you first concerned with your child's development?

10. At what age did a teacher first voice concern regarding your child's development?

11. At what age did a medical professional first express concern regarding your child's development?

12. When you first expressed concern to a medical professional (e.g., general practitioner, paediatrician) regarding you concerns, what response was given?

☐	Nothing to worry about
☐	Every child develops differently
☐	They are shy/anxious
☐	Another diagnosis (not ASD) identified
☐	Symptoms of ASD were identified
☐	A diagnosis of ASD was made

13. What, specifically, was the first concern that you had with your child's early development (i.e., before the age of 5 years old)?

☐	Language development
☐	Social development
☐	Routine dependence
☐	Motor skills
☐	Behaviour
☐	Medical issue

14. Did you have concerns about your child's early social development (i.e., before age 5yo)? If so, what age was your child when you first became concerned? What specifically were these concerns?

15. When you were first concerned with your child's early social development, did you consider their social difficulties 'autistic-like'?

For the following questions please check the box that most strongly applies to your child:

16. Child's birth order:

☐	Child is only child
☐	Child is first born
☐	Child is last born
☐	Child is middle born
☐	Foster child, or I don't know

17. Concerning baby's health in first 3 months:

☐	Excellent health, no problems
☐	Respiration problems
☐	Skin rashes/allergies
☐	Feeding problems
☐	Diarrhoea or constipation
☐	Several health problems

18. In the first year did you child respond to bright light, bright colours, or unusual sounds?

☐	Unusually strong reaction
☐	Unusually unresponsive
☐	Average
☐	Don't know

19. Age 4-6 months, did the child reach out to prepare self to be picked up when parent approached?

☐	Yes
☐	No, I don't think so
☐	No definitely not
☐	Don't know

20. At what age did the child learn to walk?

☐	8-12 months
☐	13-15 months
☐	16-18 months
☐	19-24 months
☐	25 to 36 months
☐	37 months or later, or does not walk alone

Unless otherwise specified, the following questions refer to concerns you may have held for your child during the PRE-SCHOOL YEARS (i.e., before 5 years of age)

21. During the child's first 2 years did she like to be held?

☐	Liked being picked up, enjoyed being held
☐	Limp on being held
☐	Only could hold when and how child

	preferred
☐	Still and awkward to hold
☐	Don't know

22. Before age 3, did you child ever imitate another person?

☐	Yes, simple actions e.g., waved goodbye
☐	Yes, played imitation games (e.g., pat-a-cake)
☐	Imitated multiple actions
☐	No imitation
☐	No

23. Would you describe your child around age 3-4years as often seeming withdrawn or distant so you could not reach her?

☐	Yes, this is a very accurate description
☐	Once in a while she would be like this
☐	Not an accurate description

24. Did you child like to line things up precisely and insist they weren't disturbed?

☐	No
☐	Yes

25. From 3-5 years of age was your child unusually interested in mechanical objects such as the stove or vacuum?

☐	Little or no interest
☐	Average interest
☐	Fascinated by certain mechanical things

26. Was your child destructive?

☐	Yes, this is a problem
☐	Not deliberately or severely
☐	Not especially destructive

27. Did your child get very upset if certain things were changed (e.g., furniture or toy arrangements, doors left open)?

☐	No
☐	Yes, definitely
☐	Slightly true

28. What single description best describes your child during the pre-school years?

☐	Hyperactive, constantly moving, changing quickly between activities
☐	Watches television quietly for long periods of time
☐	Sits for long periods staring in to space or playing repetitively with objects without apparent purpose
☐	Combination of 1 and 2
☐	Combination of 1 and 3
☐	Combination of 2 and 3

29. During the pre-school years did your child seem to want to be liked by other children?

☐	Yes, unusually so
☐	Just normally
☐	Indifferent, happiest when left alone
☐	Happiest when left alone

30. Was your child sensitive and/or affectionate?

☐	Sensitive to criticism and affectionate
☐	Sensitive to criticism, *not* affectionate
☐	Not sensitive to criticism, is affectionate
☐	Not sensitive to criticism, nor affectionate

31. Was your child extremely fearful between the ages of 3 – 5 years?

☐	Yes, of strangers and certain people
☐	Yes, of certain animals, noises or objects
☐	Yes of 1 and 2
☐	Only normal fearfulness

☐	Seems unusually bold and free of fear
☐	Child ignored or was unaware of fearsome objects

32. From ages 3-5 was there a problem with your child hitting, pinching, biting or injuring themselves or others?

☐	Yes, self only
☐	Yes, others only
☐	Yes, both self and others
☐	Not a problem

33. How would you judge your child's vocabulary below the age of 5 years?

☐	Far below average, strong difficulty communicating
☐	Below average, but could still communicate with parents
☐	Below average, but could communicate with others
☐	Average, but some pronunciation issues or oddness of speech
☐	Average, no concern
☐	Above average for his/her age

34. Did your child seek to comfort others when they were upset?

☐	Yes, age appropriate, would hug or pat, but only parent
☐	Yes, age appropriate, gave comfort to parents and others they knew (e.g., peers, friends)
☐	Was highly sensitive to someone being upset
☐	No, did not seem to notice at all

35. Before the age of 5 years, could your child identify emotions?

☐	Yes, average, understood a number of simple emotions (e.g., 'happy', 'sad', 'angry')
☐	No, showed no understanding of emotions
☐	Showed understanding of only one

	emotion

36. During pre-school or kindergarten years did your child have friends?

☐	Yes, but only one or two that he/she would follow around but not necessarily interact with
☐	Yes, one or two who he/she interacted with
☐	No, did not interact at all with other children
☐	Had average number of peers that they interacted with

37. What was your child's preferred interaction style between 3 and 6 years?

☐	Observing other children's play but not participating
☐	Solitary play, rarely or never interacted or observed others
☐	Play with one particular peer
☐	'Playing' with objects but showing no particular purpose
☐	Large group play

38. What was your child's preferred play style?

☐	Physical play (e.g., running, climbing)
☐	Non-verbal pretend play with peer(s) (e.g., brushing dolls hair, pushing train about)
☐	Verbal pretend play with peer(s) (e.g., simple role plays)
☐	Solitary, did not engage in any type of play (i.e., staring into space)
☐	Solitary play (e.g., sit by self playing with puzzle, brushing dolls hair, etc)
☐	Ritualistic play (e.g., spinning wheels, lining up blocks)

39. What was your child's main obsession during the pre-school years?

40. During the pre-school years do you think you child used any strategies that helped them navigate social situations? Examples include, hanging around one friend only, keeping to themselves, mimicking other interactions, or only talking to adults). Please specify the main strategy used.

Thank you for taking the time to complete this questionnaire.