

**Relationships between social functioning, ASD symptomatology and attention to faces and non-facial stimuli in children with Autism Spectrum Disorder (ASD) and Typically Developing (TD) children**

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## STATEMENT OF AUTHORSHIP

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A handwritten signature in black ink, appearing to read "Rachel Leonard". The signature is written in a cursive, flowing style.

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Dated: May 31, 2011

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Nobody trips over mountains. It is the small pebble that causes you to stumble. Pass all the pebbles in your path and you will find you have crossed the mountain. ~Author Unknown

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## SUMMARY

Previous research has demonstrated that individuals with ASD are impaired in social orienting, fixating on salient social stimuli less frequently and for shorter durations than other groups. Early social orienting impairments may underlie the social deficits in ASD. In the majority of previous studies, social orienting was examined in a clinical setting that lacked ecological validity; potentially distracting non-social stimuli were reduced, and the child was an observer of, rather than a participant in the social interaction. As a result of mixed findings and a lack of research examining social and non-social orienting in more naturalistic settings, the exact nature of the social orienting impairment in ASD remains unclear. Additionally, as few studies have examined the relationship between social orienting and social functioning, and no studies have examined the relationship between social orienting and social behaviour in the naturalistic setting, relationships between social orienting and social functioning in both children with ASD and TD children are poorly understood. The present study aimed to replicate and extend previous research by examining the visual fixation patterns of children with ASD in a semi-naturalistic and naturalistic setting. Relationships between social functioning, severity of ASD symptomatology and visual fixation patterns to social (i.e., faces) and non-social stimuli were also examined.

Twenty high-functioning 3- to 6-year-old children with ASD and 19 matched TD children were filmed during unstructured toy-play in the presence of an examiner and parent (semi-naturalistic setting) and time fixated on faces, bodies, objects or unfocused was calculated using frame-by-frame analysis. To assess social orienting in a naturalistic setting, children were observed with peers at preschool or school; in each observation interval the presence or absence of looking at a peer's face was recorded. Theory of mind, play skills, positive social behaviour with peers, and teacher ratings of social behaviour were assessed as measures of social functioning. Severity of ASD symptomatology was evaluated using scores from the Social Communication Questionnaire.

In the semi-naturalistic setting, there were no group differences in the mean number of overall attention shifts per minute. Both groups of participants also fixated on faces and objects

for similar durations, and made a comparable number of attention shifts between faces and objects. However, participants with ASD spent a significantly greater percentage of time fixated on bodies or unfocused, and made more attention shifts involving bodies than TD children. In the naturalistic setting, children with ASD were impaired in social orienting, fixating on peers' faces on significantly fewer observation intervals than TD children.

Children with ASD who obtained higher social functioning scores fixated on peers' faces on a higher percentage of observation intervals in the naturalistic setting. They also tended to spend more time fixated on faces and shifted their attention more frequently between faces and objects, faces and bodies, and objects and bodies in the semi-naturalistic setting than those who obtained lower social functioning scores. Participants with ASD who demonstrated higher levels of ASD symptomatology tended to spend a higher percentage of overall time unfocused, were unfocused for longer durations, spent a lower percentage of overall time fixated on faces, and made fewer attention shifts between faces and objects than participants exhibiting less-severe ASD symptomatology.

TD children who made fewer attention shifts between objects and fixated on objects for longer durations in the semi-naturalistic setting tended to obtain higher social functioning scores. Those who fixated on peers' faces on a higher percentage of observation intervals in the naturalistic setting also tended to obtain higher social functioning scores.

These findings suggest that the degree of social orienting impairment observed in individuals with ASD may be dependent on the social complexity of the stimuli to be observed. However, even in more structured settings, children with ASD show atypicalities in the amount of time they spend unfocused or fixated on bodies. These findings also suggest that the relationships between social and non-social orienting and social functioning differ for children with ASD and TD children. However, the ability to orient attention to salient social stimuli in the naturalistic setting is important for social functioning for both groups of children. The relationships between social and non-social orienting and social functioning are not straightforward, and appear to be mediated by factors such as children's age, language skills, social motivation, prior learning and the social complexity of the stimuli to be viewed.



## CHAPTER 1: AUTISM AND AUTISM SPECTRUM DISORDERS

### 1.1 Chapter Overview

This chapter provides an overview of autism spectrum disorders (ASD). Diagnostic criteria and course, prevalence rates, aetiology, co-morbid diagnoses, prognosis and unresolved issues pertaining to diagnosis and co-morbidity are briefly reviewed. Following this, the social impairments of ASD are reviewed in detail, and a critical analysis of the relevant research pertaining to these deficits is presented.

### 1.2 Autistic Disorder and Autism Spectrum Disorders (ASDs)

Autistic disorder is a Pervasive Developmental Disorder (PDD) included in The Diagnostic and Statistical Manual, fourth edition, text revision (DSM-IV-TR; American Psychiatric Association [APA], 2000) and the International Classification of Diseases and Related Health Problems –Tenth Revision (ICD-10; World Health Organisation [WHO], 1992). PDDs are comprised of several diagnoses, including autistic disorder (AD), Asperger’s disorder (AsD), Pervasive Developmental Disorder - Not Otherwise Specified (PDD-NOS), Rett’s disorder, and Childhood Disintegrative Disorder (CDD). PDDs are characterised by marked impairments in development that primarily impact on social and communication skills, interests, and activities. Due to their shared impairment in communication skills, social interactions, and restricted, repetitive and stereotyped patterns of behaviour, AD, AsD and PDD-NOS are generally referred to as Autism Spectrum Disorders (ASDs).

### 1.3 Diagnostic Criteria and Course

The DSM-IV-TR (APA, 2000) and ICD-10 are the two major classification systems used to diagnose mental health problems. As the diagnostic criteria for PDDs in the DSM-IV-TR and

ICD-10 are almost identical, and the DSM-IV-TR is the more widely used diagnostic tool in Australia and the USA, the present discussion will be limited to DSM-IV-TR criteria.

The DSM-IV-TR (APA, 2000) diagnosis for AD requires the demonstration of marked impairments in reciprocal social interaction, language and communication skills, and the presence of repetitive/stereotypic patterns of behaviour and interests. Impairments should be present in each of the three areas prior to 3 years of age. Deficits in the social domain include an impaired ability to develop peer relationships, share enjoyment and interests with others, regulate social interactions, use non-verbal behaviour (e.g., gestures), and display emotional reciprocity. Communication deficits include an absence of, or delay in spoken language, impaired conversation and pretend play skills, and an atypical use of language. Finally, the repetitive behaviour domain includes intense, unusual and narrow interests, an inflexible adherence to non-functional routines, repetitive motor behaviours, and a fixation on parts of objects (APA, 2000; WHO, 1992). The full diagnostic criteria for AD, according to the DSM-IV-TR (APA, 2000), are presented in Table A1, Appendix A.

AsD shares the major behavioural characteristics of AD, however develops along a somewhat different trajectory. It is characterised by the absence of a clinically significant delay in the development of speech and language, self-help and adaptive behaviour, and no significant delay in cognitive development (APA, 2000). The full diagnostic criteria for AsD, according to the DSM-IV-TR (APA, 2000), are presented in Table A2, Appendix A.

Finally, a diagnosis of PDD-NOS is utilized when the child exhibits a significant impairment in the development of reciprocal social interactions and communication skills, and demonstrates other behavioural characteristics of AD (e.g., restricted, repetitive interests), however fails to fully meet the criteria for the other ASD subtypes. The full diagnostic criteria for PDD-NOS, according to the DSM-IV-TR (APA, 2000), are presented in Table A3, Appendix A.

Individuals with a diagnosis of AD, an IQ above 70 and an early language delay are referred to as having high-functioning autism (HFA; Rubin & Lennon, 2004). Attwood (2003)

reported that the term HFA was initially used to describe individuals who presented with the typical symptomatology for AD as children, but with age, developed better cognitive, language, social and adaptive behaviour skills relative to other children with AD. The collective term high-functioning autism spectrum disorder (HFASD) is utilized for high-functioning individuals with AD, AsD and PDD-NOS who do not exhibit a cognitive impairment (Rubin & Lennon, 2004).

AD is highly heterogeneous, with significant variations in the nature and severity of symptomatology (Schultz, 2005). This has led some researchers to suggest that there are distinct neurocognitive phenotypes within individuals diagnosed with AD (Tager-Flusberg & Joseph, 2003). Deficits in social responsiveness may range from a total absence of social interactions with others, to a desire for social interactions and friendships coupled with an impaired ability to understand social norms and conventions (Willemsen-Swinkels & Buitelaar, 2002). Similarly, while deficits in pragmatic language skills are universal to the disorder, structural language skills profiles are highly variable. They may range from an absence of any functional language or communication skills, to proficient linguistic ability with atypical intonation, rate, or tone of speech (Tager-Flusberg, 2000a; Willemsen-Swinkels & Buitelaar, 2002). Finally, cognitive skills range from significant intellectual disability to average or above-average cognitive ability (Joseph, Tager-Flusberg, & Lord, 2002), and repetitive, ritualistic behaviours may range from stereotyped preoccupations to self-mutilation (Willemsen-Swinkels & Buitelaar, 2002).

There are also variations in the developmental progression of AD. Some children show an atypical course of development from birth, while up to 50% of children display a typical developmental progression for the first 15 to 24 months of life, followed by a period of regression in their language, social, communicative or behavioural development (Landa, Holman, & Garrett-Mayer, 2007; Lord, Shulman, & DiLavore, 2004; Meilleur & Fombonne, 2009; Ozonoff, Williams, & Landa, 2005; Werner & Dawson, 2005). Additionally, some children with AD demonstrate consistent and stable symptomatology throughout development, while others show age-related

deterioration or improvement (Charman et al., 2005; Turner, Stone, Pozdol, & Coonrod, 2006; Willemsen-Swinkels & Buitelaar, 2002).

#### 1.4 Prevalence Rates

Prior to 1980, AD was considered a relatively rare condition, affecting 3 to 4 per 10,000 children (Fombonne, 2005; Wing & Gould, 1979). Recent studies have reported prevalence estimates ranging from 7.2 to 40.5 per 10,000 for AD, with an average prevalence of 20.6 per 10,000 (Fombonne, 2009); 2.6 per 10,000 for AsD; 20.8 per 10,000 for PDD-NOS; and 1 in 110 for the entire ASD spectrum (Centers for Disease Control (CDC), 2009; Fombonne, 2005). In Australia, the prevalence rate of ASD is estimated at approximately 1 in 160 individuals (MacDermott, Williams, Ridley, Glasson, & Wray, 2007). The increased incidence of ASD has been related to improved recognition of symptomatology and a broadening of the diagnostic criteria (Fombonne, Zakarian, Bennett, Meng, McLean-Heywood, 2006; Lenoir et al., 2009; Merrick, Kandel, & Morad, 2004). In particular, changes from the DSM III to DSM IV and ICD 10 may have broadened the criteria for inclusion on the spectrum (Fombonne, 2005; 2009). Other researchers have emphasised the role of environmental factors, pre- or perinatal injury, or viral infections in the increased prevalence of ASDs (Larsson et al., 2005; Wing & Potter, 2002). ASDs are more common in males than females, with male to female sex ratios ranging from 2.8:1.0 to 5.5:1.0 (CDC, 2007). Recent estimates have indicated that ASDs impact approximately 1 in 70 males (CDC, 2009). Prevalence rates are not influenced by race, economic class or ethnicity (Shriver, Allen, & Mathews, 1999).

#### 1.5 Aetiology

ASDs are behaviourally defined disorders with an unknown aetiology. Attempts to identify a common underlying physical substrate have been unsuccessful, as have attempts to identify a set of dysfunctions that are universal to all children with ASD (Hobson & Bishop, 2003). Despite this,

it is widely accepted that ASDs are biologically based disorders that result in the dysfunctional operation of the central nervous system (Volkmar & Klin, 2005). Several interrelated genetic, environmental, neurological, and immunological factors are likely to contribute to their development (Folstein & Rosen-Sheidley, 2001; Gadia, Tuchman, & Rotta, 2004; Howlin, 1999; Korvatska, Van de, Anders, & Gershwin, 2002; Larsson et al., 2005; Newschaffer, Fallin, & Lee, 2002). Differences in the underlying aetiologies of ASD may be reflected in the heterogeneous nature of ASD symptomatology (Gadia et al., 2004).

Research has consistently demonstrated that ASD has a strong genetic basis, with heritability estimated at 0.9 (Baron-Cohen & Belmonte, 2005; Zafeiriou, Ververi, & Vargiami, 2007). Twin studies indicate a concordance rate of 64 to 90% for monozygotic twins and 6 to 15% for dizygotic twins and siblings (Dawson, 2008; Sutcliffe, 2008). Siblings of children with ASD also have a 30% incidence of other developmental disabilities such as cognitive, social or language deficits (APA, 2000; Constantino et al., 2006). Relative to other groups of children, parents and siblings of those with ASD exhibit higher rates of features of the broader autism phenotype, displaying milder but qualitatively similar features of ASD (Bishop et al., 2004; Goldberg et al., 2005a; Losh, Childress, Lam, & Piven, 2008; Murphy et al., 2000). According to Dawson (2008), the overall genetic contribution to ASD is approximately 91 to 93%.

Neuropathological studies have provided evidence of atypical neurodevelopment pre- and postnatally (Bauman & Kemper, 2005; Courchesne, Carper, & Akshoomoff, 2003). Courchesne, et al. (2003) reported that head circumference growth accelerates in children with ASD between 1 to 2 and 6 to 14 months of age; displaying enlarged gray matter volumes by 2 to 3 years of age (Courchesne et al., 2001; 2003; 2004; Sparks et al., 2002). Atypicalities within the frontal and temporal lobes (Carper & Courchesne, 2005; Courchesne et al., 2001; Schmitz et al., 2006), cerebellum (Allen & Courchesne, 2003; Courchesne et al., 2001; Herbert et al., 2003; Sparks et al., 2002), parietal lobes (Belmonte & Yurgelun-Todd, 2003; Courchesne, Press, & Yeung-Courchesne, 1993; Haist, Adamo, Westerfield, Courchesne, & Townsend, 2005), and limbic

system, particularly the hippocampus and the amygdala (Baron-Cohen et al., 2000; Mosconi et al., 2006; Nacewicz et al., 2006; Schumann et al., 2004; Sparks et al., 2002), have also been documented.

Other researchers have implicated altered levels of the neurotransmitters norepinephrine (also known as noradrenaline), serotonin, and dopamine (Cook et al., 1997), metabolic atypicalities such as Pheylketonuria (Baieli, Pavone, Meli, Fiumara, & Coleman, 2003), immunological abnormalities (Ashwood & de Water, 2004; Singh, Lin, Newell, & Nelson, 2002; Vojdani et al., 2002) and gastrointestinal disturbances (Ashwood, Anthony, Torrente, & Wakefield, 2004; Horvath & Perman, 2002; Wakefield, Ashwood, Limb, & Anthony, 2005) as factors that are associated with the presence of ASD.

## 1.6 Co-morbid Disorders

According to the DSM-IV-TR (APA, 2000), ASD often co-occurs with other forms of psychopathology (Matson & Nebel-Schwalm, 2007). An emerging body of research supports the presence of co-morbid symptoms and disorders in many individuals with ASD, including intellectual disability (ID), depression, symptomatology consistent with Attention Deficit Hyperactivity Disorder (ADHD), anxiety disorders, including Obsessive Compulsive Disorder (OCD), tic disorders and other neurological and genetic disorders (Bellini, 2004; Canitano & Vivanti, 2007; Corbett & Constantine, 2006; Fombonne, 2002; Gadow, DeVincent, Pomeroy, & Azizian, 2004; Leyfer et al., 2006; Marriage, Wolverton, & Marriage, 2009; Russell, Mataix-Cols, Anson, & Murphy, 2005).

### *1.6.1 Intellectual Disability (ID)*

Approximately 70 to 75% of individuals diagnosed with AD have a co-morbid ID (APA, 1994; Fombonne, 2005). An ID is characterized by a significantly below-average score on a test of cognitive ability and impaired adaptive behaviour (CDC, 2007). Individuals with PDD-NOS may also have a co-morbid ID. While AsD is usually characterised by the absence of an ID, cases of a

co-morbid ID in AsD have been reported according to the DSM-IV-TR (APA, 2000) and ICD-10 (WHO, 1992).

However, Edelson (2006) suggested that the prevalence of co-morbid ID in individuals with AD may be significantly lower than estimated. Following a review of 213 studies, Edelson proposed that prevalence estimates were outdated, failed to account for important aspects of autistic symptomatology that may influence test results (e.g., the motivation of participants), that conclusions were not based on sound empirical data, and that developmental and adaptive scales, rather than standardized assessments of cognitive ability, were utilized in many cases.

### *1.6.2 Depression*

Several researchers have reported that depression may be one of the most common co-morbid disorders associated with ASD (Ghaziuddin, Ghaziuddin, & Greden, 2002; Kim, Szatmari, Bryson, Streiner, & Wilson, 2000; Stewart, Barnard, Pearson, Hasan, & O'Brien, 2006). The prevalence rates of depression in ASD vary significantly, from approximately 4 to 38% (Ghaziuddin, Weidmer-Mikhail, & Ghaziuddin, 1998; Lainhart, 1999). Other studies have reported that the rates of co-morbid depression are lower for more severely impaired individuals, than those with HFASD (Leyfer et al., 2006). However, several researchers have suggested that the prevalence of co-morbid depression may be significantly higher than estimated in individuals with AD. True prevalence rates may be obscured by difficulties assessing individuals with verbal and cognitive impairments, and an atypical presentation of depression in ASD (Stewart et al., 2006).

For individuals with ASD, depressed mood was the most commonly reported symptom of depression. A loss of interest in activities, sleep and eating disturbances were also reported (Stewart et al., 2006). However, the majority of studies examining depression in ASD relied on third-party reports of observable behaviours rather than self-report (Stewart et al., 2006). Additionally, few studies employed non-ASD comparison groups or methodical sampling procedures, thereby limiting the interpretability of findings (Stewart et al., 2006).

### *1.6.3 Attention Deficit Hyperactivity Disorder (ADHD)*

Converging evidence suggests that a high percentage of individuals with ASD display symptomatology consistent with ADHD (Corbett & Constantine, 2006; Gadow, DeVincent, & Pomeroy, 2006; Gadow et al., 2004; Goldstein & Schwebach, 2004; Happé, Booth, Charlton, & Hughes, 2006; Hurtig et al., 2009; Lee & Ousley, 2006; Marriage et al., 2009). The primary features of ADHD are hyperactivity and impulsivity and / or inattention that are developmentally inappropriate and substantially impair functioning (APA, 2000). While a diagnosis of ASD and ADHD are mutually exclusive in the DSM-IV-TR, several researchers have reported that up to 50% of children with ASD demonstrate attentional deficits and heightened activity levels (Gillberg & Billstedt, 2000; Goldstein & Schwebach, 2004; Leyfer et al., 2006; Yoshida & Uchiyama, 2004). Additionally, individuals with both ASD and ADHD display neurological impairments in the frontostriatal system including the frontal lobes and basal ganglia (Courchesne & Pierce, 2005; Mostofsky, Cooper, Kates, Denckla, & Kaufmann, 2002; Schmitz et al., 2006), and show related deficits in executive functions (Geurts, Verte, Oosterlaan, Roeyers, & Sergeant, 2004; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005). Finally, both ASD and ADHD are childhood onset disorders with a strong genetic component (Goldstein & Schwebach, 2004; Holtmann, Bolte, & Poustka, 2005; Stahlberg, Soderstrom, Rastam, & Gillberg, 2004; Sturm, Fernell, & Gillberg, 2004). Evidence suggests that ASD and ADHD may be genetically linked at chromosome locations 2q24 and 16p13 (Fisher et al., 2002; Ogdie et al., 2003).

### *1.6.4 Anxiety Disorders*

Existing research indicates that children and adults with HFASD experience significantly higher levels of anxiety than the general population (Bellini, 2004; Hurtig et al., 2009; Kim et al., 2000; Meyer, Mundy, Van Hecke, & Durocher, 2006; Weisbrot, Gadow, DeVincent, & Pomeroy, 2005; for a review see MacNeil, Lopes, & Minnes, 2009). The level of anxiety experienced by these individuals is comparable to that of clinically anxious samples (Farrugia & Hudson, 2006; Russell & Sofronoff, 2005). While a broad range of anxiety symptoms are exhibited by individuals



with ASD, Farrugia and Hudson (2006) reported that obsessive–compulsiveness, social phobia, and generalized anxiety were the most commonly reported anxiety symptoms. Other research suggests that anxiety symptomatology may differ across ASD subtypes, with individuals with AsD and PDD-NOS reportedly experiencing higher levels of anxiety symptoms than those with AD (Thede & Coolidge, 2007; Weisbrot et al., 2005). This suggests that individuals with less-severe ASD symptomatology may experience higher levels of anxiety than those with relatively more symptomatology (MacNeil et al., 2009). However, conclusions from these studies are limited by small sample sizes, conflicting findings (Kim et al., 2000; Pearson et al., 2006), and numerous methodological limitations (e.g., a reliance on rating scales rather than multi-modal assessment protocols to examine anxiety, and lack of appropriately matched control groups; MacNeil et al., 2009).

#### *1.6.5 Obsessive Compulsive Disorder (OCD)*

One of the most common anxiety disorders exhibited with individuals with ASD is Obsessive Compulsive Disorder (OCD; DeBruin, Ferdinand, Meester, de Nijs, & Verheij, 2007; Gillott, Furniss, & Walter, 2001; Leyfer et al., 2006; Russell et al., 2005). However, prevalence rates are highly variable. In a study of 109 children and adolescents with AD, Leyfer et al. (2006) reported that 37% of participants met the DSM-IV diagnostic criteria for OCD. More recently, DeBruin et al. (2007) reported 8.5% of 6- to 12-year-old children with PDD-NOS exhibited symptomatology consistent with a diagnosis of OCD.

OCD symptomatology observed in individuals with ASD includes obsessions and compulsions with associated distress (Levallois, Béraud, & Jalenques, 2007; Marriage et al., 2009; Russell et al., 2005; Zandt, Prior, & Kyrios, 2006), deficits in executive functions (Russell et al., 2005), and a resistance to change (Steketee & Pigott, 2006). Similar neurological impairments in the frontal lobe, cerebellum, hippocampus, and amygdala of individuals with ASD and OCD have also been noted (Baron-Cohen, 2004; Boucher et al., 2005; Dziobek, Fleck, Rogers, Wolf, & Convit, 2006), as well as neurobiochemical imbalances in neurotransmitters such as serotonin and

dopamine (Gross-Isseroff, Hermesh, & Weizman, 2001; Steketee & Pigott, 2006). Finally, a common pattern of co morbid disorders exist for ASD and OCD, including other anxiety disorders (Bhardwaj, Agarwal, & Sitholey, 2005; Cath, Ran, Smit, van Balkom, & Comijs, 2008; Gillott et al., 2001; Leyfer et al., 2006) and tic disorders (Marriage et al., 2009; Ringman & Jankovic, 2000).

#### *1.6.6 Tic Disorders*

Tic disorders are characterized by an abrupt, rapid, and recurring stereotyped vocalization or movement (APA, 2000). The four tic disorders identified in the DSM-IV-TR are Transient Tic Disorder, Chronic Motor or Vocal Tic Disorder, Tourette's Disorder, and Tic Disorder Not Otherwise Specified. A number of researchers have noted the co-occurrence of tics in ASD (Baron-Cohen, Scahill, Izaguirre, Hornsey, & Robertson, 1999; Canitano & Vivanti, 2007). In a sample of 105 children and adolescents with ASD, Canitano and Vivanti (2007) reported that 22% of participants exhibited tic disorders; including Tourette disorder (11%) and motor tics (11%). They further reported a strong association between the presence of a tic disorder and ID.

Behavioural and clinical similarities between tic disorders and ASD (e.g., abnormal motor movements and repetitive vocalisations) complicate differential diagnosis (Baron-Cohen et al., 1999). However, there are important quantitative, qualitative and functional differences between the behaviours. Tic behaviours are sudden, rapid, irregular, variable, asymmetrical, and occur in clusters; often in response to physical stress. These behaviours may occur in sleep, and may remit for prolonged periods of time. While individuals with a tic disorder may experience secondary social consequences as a result of their disorder, they do not demonstrate the primary impairments in social interactions, language and communication skills that characterize ASD. In contrast, ritualistic behaviours observed in ASD are often rhythmic, calming, bilateral, or generalized (e.g., flapping or jumping). They have a younger age of onset, and do not occur in sleep (APA, 2000).

#### *1.6.7 Additional Neurological and Genetic Disorders*

Finally, AD co-occurs with a number of neurological and genetic disorders in 6 to 10% of individuals (Marriage et al., 2009). These include tuberous sclerosis, Fragile X syndrome,

congenital rubella, and phenylketonuria (Cohen et al., 2005; Filipek et al., 2000; Wiznitzer, 2004; Zafeiriou et al., 2007). Epilepsy also occurs between 16 to 40% of individuals with ASD (Tuchman & Rapin, 2002), with a higher incidence of epilepsy evident in individuals with a co-morbid ID.

### 1.7 Prognosis

The long-term prognosis for individuals with ASD is highly variable. While evidence suggests that there are functional improvements and a reduction in ASD symptomatology over time (Charman et al., 2005; Fecteau, Mottron, Berthiaume, & Burack, 2003; Howlin, 2000; Howlin, Goode, Hutton, & Rutter, 2004; Howlin, Mawhood, & Rutter, 2000; Mawhood, Howlin, & Rutter, 2000; Seltzer, Shattuck, Abbeduto, & Greenberg, 2004; Turner et al., 2006), the majority of these individuals continue to demonstrate a significant degree of disability in adulthood (Cederlund, Hagberg, Billstedt, Gillberg, & Gillberg, 2008; Howlin, 2000; Howlin et al., 2000; 2004; Marriage et al., 2009; Mawhood et al., 2000; Seltzer et al., 2004). Significant impairments in social and communication skills, behaviour, cognitive and adaptive functioning are evident; characterized by a failure to develop independence or interpersonal relationships, a lack of vocational achievements, and the persistence of stereotyped behaviours (Cederlund et al., 2008; Engstrom, Ekstrom, & Emilsson, 2003; Howlin, 2000; Howlin et al., 2004; Marriage et al., 2009; Seltzer et al., 2004). However, a sub-group of 15 to 30% of adults with ASD demonstrate more positive outcomes, attaining satisfactory social, occupational, adaptive and academic functioning (Cederlund et al., 2008; Engstrom et al., 2003; Howlin et al., 2000; Marriage et al., 2009; Mawhood et al., 2000; Seltzer et al., 2004; Toth, Munson, Meltzoff, & Dawson, 2006). In interpreting the findings of outcome studies in ASD, Baghdadli et al. (2007) cautioned that generalizations from long-term outcome studies in ASD were difficult due to the use of highly heterogeneous subject populations comprised of individuals with different disorders (i.e., AD, HFA, AsD, PDD-NOS), small sample sizes, and considerable variability in the assessment measures utilized. Additionally, outcome ratings (e.g., good, satisfactory and poor) were not based on a common and consistent criteria

across studies, and the use of global measures (e.g., cognitive ability) as prognostic indicators may miss important aspects of pathological development (Baghdadli et al., 2007; Pry, Petersen, & Baghdadli, 2005).

Other research indicates that the long-term prognosis of individuals with ASD is dependent on a number of factors, including the severity of symptomatology, cognitive functioning, language abilities, age, and treatment (Helt et al., 2008). Research has consistently demonstrated that one of the most important predictors of positive outcome for individuals with AD is the acquisition of functional spoken language skills prior to 5 or 6 years of age (Baghdadli et al., 2007; Helt et al., 2008; Howlin et al., 2000; Howlin et al., 2004; Sigman & Ruskin, 1999). According to some researchers, there is also a link between outcome and the severity of ASD symptomatology (Eaves & Ho, 1996). Other researchers have failed to support such a link (Helt et al., 2008).

Long-term outcome studies have also demonstrated that individuals with ASD and a co-morbid ID have significantly worse outcomes than those with cognitive abilities within the normal range (Cederlund et al., 2008; Helt et al., 2008; Howlin et al., 2004; Marriage et al., 2009). However, a wide range of adult outcome for individuals with HFASD has been documented (Howlin et al., 2004; Marriage et al., 2009), with several researchers suggesting that neither verbal IQ (VIQ) nor performance IQ (PIQ) consistently indicate prognosis on an individual level (Howlin et al., 2004; Marriage et al., 2009). Marriage et al. (2009) reported that the independence, vocational achievement and social functioning of many individuals with HFASD were not commensurate with their cognitive ability. This was attributed to a combination of social, sensory and executive function impairments in these individuals. Other studies have supported this notion, citing lower levels of independence and a high prevalence of co-morbid psychiatric impairment within individuals with HFASD (Cederlund et al., 2008; Engstrom et al., 2003; Helt et al., 2008; Howlin, 2000).

Finally, participation in specialized intervention programs such as social skills training, vocational instruction, and behavioural intervention has resulted in significant functional

improvements for individuals with ASD (Renty & Roeyers, 2006). While there is a paucity of long-term outcome studies examining the efficacy of intensive intervention in adulthood, a reduction in ASD symptomatology and notable improvements in social, language, and cognitive ability have been documented following early, comprehensive, and intensive behavioural interventions for young children with ASD (Cohen, Amerine-Dickens, & Smith, 2006; Eldevik, Eikeseth, Jahr, & Smith, 2006; Helt et al., 2008; Howard, Sparkman, Cohen, Green, & Stanislaw, 2005; Lovaas, 1987; 1993; McEachin, Smith, & Lovaas, 1993; Sallows & Graupner, 2005). Other studies have shown a reduction of ASD symptomatology, and improvements in expressive language and communication skills following parent training (Aldred, Green, & Adams, 2004; for a review see Rogers & Vismara, 2008). Evidence further indicates that children who begin specialized intervention at an early age may have a better outcome than those who begin at an older age (Altemeier & Altemeier, 2009; Dawson, 2008; Harris & Handleman, 2000).

## 1.8 Summary

AD, AsD and PDD-NOS belong to a spectrum of disorders characterised by impairments in communication skills, social interactions, and restricted, repetitive and stereotyped patterns of behaviour. These disorders are collectively known as ASDs. The current prevalence is approximately 1 in 110 for the entire ASD spectrum (CDC, 2009). While the cause of ASD is unknown, it is widely accepted that there is a strong genetic component. Interplay between several genetic, environmental, neurological and immunological factors likely leads to its development. ASD co-occurs with a number of psychiatric, genetic and neurological conditions, including ID, depression, ADHD, anxiety disorders and tic disorders. The long-term prognosis of individuals with ASD is highly variable, and depends on several factors including cognitive abilities, the acquisition of language skills in early childhood and treatment.

## 1.9 Unresolved Issues

There are several unresolved issues related to diagnosis and co-morbidity in ASD.

First, while early emerging symptoms, such as a lack of eye-contact and joint social attention, are central to the diagnosis of ASD (Baranek, 1999; Clifford, Young, & Williamson, 2007; Maestro et al., 2005; Osterling, Dawson, & Munson, 2002), researchers and clinicians remain undecided on the primary impairment. As the current diagnostic criteria from the DSM-IV-TR and ICD-10 rely on behavioural symptomatology that is identifiable after approximately 2 years of age (e.g., atypical language and social interactions with peers; Young & Brewer, 2002), the average age of diagnosis is approximately 3 years. However, prospective studies of infant siblings of children with ASD (Ibanez, Messinger, Newell, Lambert, & Sheskin, 2008; Zwaigenbaum et al., 2005) and the retrospective analysis of infants later diagnosed with ASD (Baranek, 1999; Clifford et al., 2007; Maestro et al., 2005; Osterling & Dawson, 1994; Osterling et al., 2002; Watson et al., 2007; Werner, Dawson, Munson, & Osterling, 2005; Werner, Dawson, Osterling, & Dinno, 2000) have demonstrated that infants who are later diagnosed with ASD may show some identifiable symptomatology by approximately 12 months of age. Identification of the earliest emerging symptomatology that reliably characterizes ASD would allow for the earlier diagnosis and treatment of children with ASD (Clifford et al., 2007).

Second, the symptomatology and developmental trajectory of individuals with ASD varies significantly according to their age, language development, and cognitive ability (Charman et al., 2005; Fecteau et al., 2003; Sigman & McGovern, 2005; Sigman & Ruskin, 1999). However, the diagnostic criteria utilized in the DSM-IV-TR (APA, 2000) and ICD-10 (WHO, 1992) aims to encapsulate the broad range of presentations. As a result, there is considerable heterogeneity in the symptom severity, prognosis and developmental trajectory of children diagnosed with ASD. (Charman et al., 2005; Fecteau et al., 2003). In response to these issues, Volkmar and Klin (2005) proposed that the development of diagnostic criteria that specifically addresses differences in age, cognitive, and language development, would decrease diagnostic dilemmas and improve the

interpretability and generalization of research findings. It would also allow for the development and implementation of more targeted treatment programs according to the nature and degree of impairment.

Third, the classification of AsD as a distinct diagnostic category from the other PDDs, has generated a significant amount of controversy, as noted in the ICD-10. The key issue is whether AsD is qualitatively different from AD, or a variant of HFA. This issue has generated diagnostic dilemmas and concerns regarding the validity of a separate diagnosis from HFA, which has neither been equivocally supported nor refuted (Leekam, Libby, Wing, Gould, & Gillberg 2000; Wing, 2005). Previous research studies attempting to discriminate between AsD and HFA have obtained mixed results. Several studies have established few qualitative differences between AsD and HFA, reporting that many of the neuropsychological, social cognitive and biological symptomatology are either shared or overlapping (Ghaziuddin & Mountain-Kimchi, 2004; McIntosh & Dissanayake, 2004). Howlin (2003) additionally noted that the long-term outcome of individuals with AsD and HFA does not significantly differ once cognitive abilities have been controlled for. Other researchers have supported the notion of qualitative differences between AsD and HFA, reporting that individuals with AsD and HFA have distinctly different cognitive profiles. Individuals with AsD often demonstrate higher verbal than performance IQ scores, while the opposite trend is observed for those with HFA (Rubin & Lennon, 2004; Tsatsanis, 2004). Individuals with AsD also show less severe language and communication atypicalities in adulthood, and demonstrate more variable motor deficits than those with HFA (APA, 2000; Huang & Wheeler, 2006).

Finally, while evidence suggests that individuals with ASD are at increased risk of other psychiatric conditions, the exact prevalence is poorly understood. There is considerable variability in the reported prevalence of co-morbid disorders associated with ASD, and uncertainty regarding whether the symptomatology observed indicates the presence of a co-morbid condition, or is an expression of ASD symptomatology (MacNeil et al., 2009; Matson & Nebel-Schwalm, 2007). It is also unclear whether ASD increases the risk of other psychiatric conditions (Bradley, Summers,

Wood, & Bryson, 2004; LaMalfa et al., 2007), or whether the increased prevalence of these conditions stems from other co-morbid conditions, such as cognitive impairment. These factors are exacerbated by the considerable clinical and aetiological heterogeneity in individuals with ASD.

Difficulties diagnosing co-morbid conditions in individuals with ASD may be attributed to the lack of valid, reliable diagnostic instruments for these individuals (Leyfer et al., 2006; McBrien, 2003). Standardized tools for assessing psychiatric disorders rely on extensive communication skills, and the ability to reflect on one's internal states. However, many individuals with AD display considerable limitations in their verbal, communicative and cognitive abilities. For individuals with proficient language skills, other impairments in communication, executive functions, information processing and understanding mental states and concepts are often present (Leyfer et al., 2006). As a result of these impairments, standardized assessment tools for examining the presence of psychiatric disorders in the general population may be inappropriate for use with individuals with ASD (Leyfer et al., 2006). As the majority of studies examining the co-morbid presence of psychiatric conditions in individuals with ASD have failed to utilize instructions that were specifically designed or adapted for these individuals, their findings should be interpreted with caution.

Finally, research studies examining co-morbid psychiatric conditions in ASD are limited by a number of additional methodological constraints. These include a significant degree of heterogeneity in the sample populations, different sampling procedures, and lack of consistency in the diagnostic assessments utilized. Inclusion criteria, age of participants, assessments used, and reasons for referral also differed significantly across studies (Stewart et al., 2006). Several studies only examined current symptomatology. Others only included participants who were referred for treatment for psychiatric conditions. The majority of research was also conducted with children with HFASD who were able to verbalize their symptoms, thereby under-representing those with more significant impairments in their language or cognitive skills (Bradley et al., 2004).



## 1.10 Social Deficits in ASD

It is widely asserted that social impairments, or abnormalities in reciprocal social interactions and understanding, are the primary deficits observed in children with an ASD (APA, 2000; Bauminger, 2002). These behaviours are considered both qualitatively and quantitatively different from social behaviour observed in typically developing (TD) children, and from children with other childhood disorders. Such impairments are well documented in the literature and include impairments in non-verbal behaviour (Carpenter, Pennington, & Rogers, 2002; Colgan et al., 2006; Dawson et al., 2002; 2004; Leekam & Ramsden, 2006; Leekam, Libby et al., 2000; MacDonald et al., 2006; Naber et al., 2008; Osterling et al., 2002; Sigman & McGovern, 2005; Sullivan et al., 2007; Toth et al., 2006), low responses to social bids from peers (Jackson et al., 2003), problems initiating, regulating and sustaining reciprocal social interactions (Bauminger, Shulman, & Agam, 2003; Loncola & Graig-Unkefer, 2005), difficulties differentiating and classifying emotions (Hobson, 1986), and deficits or delays in understanding others' viewpoints (Jackson et al., 2003). As a result, children with ASD experience profound difficulties establishing and sustaining meaningful, age-appropriate friendships with their peers (Howlin et al., 2004; Jackson et al., 2003; Orsmond, Krauss, & Seltzer, 2004).

Several researchers have reported that social dysfunction may be central to understanding ASD (Bodfish, Symons, Parker, & Lewis, 2000). First, social deficits are specific to ASD, while deficits in the domains of communication and language skills, and repetitive, self-stimulatory behaviours, are commonly reported in individuals with language disorders and an ID respectively (Bodfish et al., 2000; Tager-Flusberg & Cooper, 1999). Significant deficits in the development of reciprocal social interaction are also a common feature of all ASD subtypes. Second, social dysfunction may underlie the other areas of impairment associated with ASD. Early impairments in the development of social motivation (Dawson, Meltzoff, Osterling, Rinaldi, & Brown, 1998; 2004; Mundy & Neal, 2001), non-verbal communication skills (Carpenter et al., 2002; Colgan et al., 2006; Dawson et al., 2002; 2004; Leekam & Ramsden, 2006; Leekam, Libby et al., 2000;

MacDonald et al., 2006; Naber et al., 2008; Osterling et al., 2002; Sigman & McGovern, 2005; Sullivan et al., 2007; Toth et al., 2006) and mental-state understanding (Tager-Flusberg, 2000b; Tager-Flusberg & Joseph, 2005) impair the development of language and communication skills. Additionally, studies have shown that the core language skills are relatively intact in high-functioning individuals with ASD (Boucher, 2003; Walenski, Stewart, Mostofsky, Gidley-Larson, & Ullman, 2008; Walenski, Tager-Flusberg, & Ullman, 2006), with universal deficits observed in the social or pragmatic aspects of language (Boucher, 2003; Martin & McDonald, 2003; Ozonoff & Miller, 1996; Volden, Coolican, Garon, White, & Bryson, 2009). Social dysfunction has also been documented in infants with ASD prior to the age at which restricted and repetitive behaviours typically emerge (Maestro et al., 2002; Moore & Goodson, 2003; Schultz, 2005), and a link between early social deprivation and the development of restricted, repetitive behaviour has been documented in non-human primates following severe social deprivation (Harlow, Dodsworth, & Harlow, 1965; McKinney, 1974), children with severe cognitive impairments (Bodfish et al., 2000), and in institutionally deprived children (Beckett et al., 2002; O'Connor, Rutter, Beckett, Keaveney, & Kreppner, 2000).

### *1.10.1 Non-Verbal Social Behaviour*

Throughout their first year of life, infants learn to communicate non-verbally through the use of eye-contact, pre-linguistic gestures and vocalizations. These behaviours act as a means of early self-expression, and serve to establish and maintain social interactions with others (Stone, Ousley, Yoder, Hogan, & Hepburn, 1997). With development, non-verbal communication becomes more complex and varied. Infants not only demonstrate an increase in the rate and variability of their communicative acts, they develop the ability to coordinate multiple non-verbal and vocal behaviours simultaneously (e.g., gestures and sounds; Stone, Ousley, Yoder et al., 1997).

‘Gestures’ are non-verbal actions used to communicate with others, and are typically expressed through the use of fingers, hands, arms, and, to a lesser degree, facial expressions and

body movements (Iverson & Thai, 1998). Three main communicative functions have been identified for gestures in TD children (Bruner, 1981). These include social interaction, behaviour regulation, and joint attention (JA). Social interaction refers to the use of gestures for sustaining a social game or routine, providing comfort, or showing off. Behaviour regulation gestures refer to gestures used to request actions, request objects, and protest. Finally JA gestures refer to behaviours used to direct another's attention, comment on an object or event, provide information, or share attention. JA gestures involve the triadic coordination of attention between two people and an object or event, where both individuals are aware of the attentional focus of the other (Colgan et al., 2006; Crais, Douglas, & Campbell, 2004). JA behaviours include shifting gaze between an event or object and a person, and may be combined with pointing or showing. JA behaviour may also include responding to pointing, showing, and / or a gaze shift initiated by another person. In this section, research pertaining to the JA behaviours of shifting gaze between an event or object and a person with pointing or showing will be discussed. Following the gaze shift of another person will be discussed in Chapter 4, Section 4.7.

By the end of their second year of life, TD infants use a range of gestures such as pointing, showing, offering and giving, for imperative (behavioural regulation), and declarative (JA) purposes (Camaioni, Perucchini, Muratori, Parrini, & Cesari, 2003). Some researchers have proposed that prelinguistic development occurs in an ordered sequence (Carpenter, Nagell, & Tomasello, 1998) with specific types of gestures emerging at different points in development. Reaching develops at 6 to 9 months of age, with giving and showing emerging between 8 to 13 months of age. Finally, pointing emerges from 9 to 14 months of age (Crais et al., 2004).

Previous research examining the nature of children with ASDs' non-verbal communication has consistently shown that these children are impaired in both their use and understanding of non-verbal behaviours to initiate, maintain and regulate social interactions. Impairments have been noted in both the quantitative and qualitative use of gestures (Carpenter et al., 2002; Chiang, Soong, Lin, & Rogers, 2008; Dawson et al., 2002; 2004; Landa et al., 2007; Leekam & Ramsden,

2006; Leekam, Libby et al., 2000; MacDonald et al., 2006; Mundy, Sigman, & Kasari, 1990, Naber et al., 2008; Osterling et al., 2002; Sigman & McGovern, 2005; Stone, Ousley, Yoder et al., 1997; Sullivan et al., 2007; however, see Macintosh & Dissanayake, 2006). However, children with ASD are significantly more impaired in their use of gestures with a social function (e.g., gestures for initiating or responding to JA bids; Carpenter et al., 2002; Colgan et al., 2006; Dawson et al., 2002; 2004; Leekam & Ramsden, 2006; Leekam, Libby et al., 2000; MacDonald et al., 2006; Naber et al., 2008; Osterling et al., 2002; Sigman & McGovern, 2005; Sullivan et al., 2007; Toth et al., 2006), than those utilised for the function of behaviour regulation and goal attainment (Leekam & Ramsden, 2006; MacDonald et al., 2006; Whalen & Schreibman, 2003).

In an early study, Stone, Ousley, Yoder et al. (1997) examined the nature, function and complexity of non-verbal communication skills in young children with ASD. Fourteen 2- to 3-year-old children with ASD, and children with a developmental delay (DD) and/or language impairment matched on chronological age (CA), mental age (MA), and expressive vocabulary participated in the study. Participants undertook a structured communication assessment designed to elicit non-verbal requesting and commenting behaviour. Results indicated that participants with ASD pointed, showed objects, and used eye-contact to communicate at a significantly lower frequency than control subjects. They demonstrated a more restricted range of non-verbal behaviour overall, and used less complex combinations of behaviours in their social interactions. They were also more likely to engage in physical manipulation than gestures to communicate with others (e.g., manipulating the examiners hand to gain access to a desired item rather than using a gesture). Similar findings were obtained by Carpenter et al. (2002), who examined whether the non-verbal communication skills of 2.5- to 4.5-year-old children with ASD differed from DD children matched on CA, verbal mental age (VMA), and non-verbal mental age (NVMA). In this study, participants were presented with four situations designed to elicit declarative (sharing) and imperative (requesting) gestures. Results indicated that while children with ASD produced

significantly fewer declarative gestures than DD children, groups did not differ in their production of imperative gestures.

More recently, Colgan et al. (2006) used retrospective video analysis to examine the early development of social interaction gestures in 21 infants later diagnosed with ASD and 14 TD infants. Video footage from when the infants were aged between 9 and 12 months was analysed. The presence and frequency of gestures that were directed towards another person and served the function of social interaction were scored and included waving, playing peek-a-boo, clapping, dancing and nodding head. Results indicated that infants who demonstrated a restricted repertoire of gestures were more likely to receive an ASD diagnosis than infants who exhibited a wide variety of gesture behaviours. The overall frequency of gestures failed to predict group membership.

Finally, Landa et al. (2007) examined the early social communication skills of 17 low-risk children with no family history of ASD, and high-risk siblings of children with ASD (SIBS-A). SIBS-A were classified on the basis of their diagnostic outcome at 3 years of age according to whether they received an early ( $n = 16$ ) or late ( $n = 14$ ) diagnosis of ASD; showed symptomatology of the broader autism phenotype without meeting the diagnostic criteria for ASD ( $n = 19$ ); or whether they demonstrated articulation or motor impairments in the absence of broader autism phenotype symptomatology ( $n = 58$ ). Participants were evaluated at 14 and 18 months using the Communication and Symbolic Behaviour Scales Developmental Profile (CSBS DP; Wetherby & Prizant, 2002). Results indicated that, at 14 months of age, children who received an early diagnosis of ASD showed a smaller range of gestures and used gestures for behaviour regulation and JA significantly less frequently than children who received a later diagnosis of ASD, and all other groups of participants. By 2 years of age, participants who received a later-diagnosis of ASD did not differ from participants who received an early diagnosis of ASD in their non-verbal communicative skills, however they demonstrated a more restricted inventory of gestures. They also initiated JA and behaviour regulatory bids significantly less frequently than other groups of participants.

A commonly used assessment to examine JA in infants and children is the Early Social Communication Scale (ESCS; Mundy et al., 2003). The ESCS is a structured assessment in which an examiner presents the child with a series of engaging active, wind-up toys, turn-taking activities (such as rolling a ball or wearing glasses or a hat) and social games (such as tickle games). The examiner also presents the child with opportunities to follow JA bids, by calling the child's name and pointing to a series of posters positioned on the walls of the room. Scores for initiating and responding to JA bids, and initiating and responding to behaviour requests are obtained.

Using the ESCS, Rutherford and Rogers (2003) reported that children with ASD (Mean CA = 2.8 years) were significantly impaired in initiating JA bids relative to CA- and- MA- matched DD children (Mean CA = 2.9 years). Similarly, MacDonald et al. (2006), reported that 2- to 4-year-old children with ASD demonstrated minor deficits in responding to JA, and significant impairments in initiating JA relative to CA-matched TD children. Leekam and Ramsden (2006) administered the ESCS to 19 children with ASD (Mean CA = 4.3 years) and 20 DD children (Mean CA = 4.5 years) individually matched on non-verbal ability. The results showed that children with ASD initiated significantly fewer acts of JA, however they did not differ from DD children in their response to JA bids. Finally, Chiang et al. (2008) administered the ESCS to 23 toddlers with ASD (Mean CA = 2.7 years), 23 DD toddlers matched with the ASD group on MA and CA (Mean CA = 2.8 years), 22 TD toddlers matched with the ASD and DD groups on MA (Mean CA = 1.6 years), and an additional 22 TD toddlers (Mean CA = 1.2 years) matched with the aforementioned TD group on IQ. Results indicated that toddlers with ASD initiated JA and responded to the JA bids of others significantly less frequently than both DD and TD toddlers. Taken together, these studies indicate that children with ASD are significantly impaired in initiating JA relative to other groups of children.

#### *1.10.1.1 Summary of Research Examining Non-Verbal Social Behaviour in ASD*

Research examining the development of non-verbal social behaviour in individuals with ASD has demonstrated that these individuals use fewer gestures (Carpenter et al., 2002; Chiang et

al., 2008; Dawson et al., 2002; 2004; Landa et al., 2007; Leekam & Ramsden, 2006; Leekam, Libby et al., 2000; MacDonald et al., 2006; Mundy et al., 1990, Naber et al., 2008; Osterling et al., 2002; Sigman & McGovern, 2005; Stone, Ousley, Yoder et al., 1997; Sullivan et al., 2007), a more limited repertoire of gestures (Colgan et al., 2006; Stone, Ousley, Yoder et al., 1997) and gestures typical of a lower developmental level (Stone, Ousley, Yoder et al., 1997) than children of similar age and developmental level. More pronounced impairments were observed for initiating declarative gestures (i.e., for purely social purposes), relative to the use of imperative gestures for goal attainment (Carpenter et al., 2002). Impairments were also more prominent for initiating, rather than responding to the JA bids of others (Leekam & Ramsden, 2006; MacDonald et al., 2006; Whalen & Schreibman, 2003). Finally, individuals with ASD appear to use less complex combinations of non-verbal behaviour to communicate, employing a higher proportion of isolated gestural acts rather than gestures combined with vocalizations (Stone, Ousley, Yoder et al., 1997). Deficits in non-verbal social behaviours were present in individuals with ASD relative to children of similar age and developmental level, and the development of JA may be influenced by cognitive skills such as memory, information processing, self-monitoring and inhibition (Mundy & Acra, 2006; Mundy & Sigman, 2006; Mundy et al., 2007; Nichols, Fox, & Mundy, 2005). Other researchers have reported that differences in responding to JA are most prominent for individuals with ASD with lower cognitive abilities (Leekam, Hunnisett, & Moore, 1998; Leekam, Libby et al., 2000; Leekam & Ramsden, 2006), and that the severity of deficits in some non-verbal social behaviours (e.g., responding to JA) decrease with development (Leekam & Moore, 2001).

#### *1.10.1.2 Limitations of Research Examining Non-Verbal Social Behaviour in ASD*

Many studies examining the non-verbal social behaviour of individuals with ASD examined a restricted range of conventional gestures, predominantly related to JA (e.g., pointing or showing; Osterling & Dawson, 1994; Osterling et al., 2002). Consequently, it is unclear whether individuals with ASD use significantly fewer gestures in their social interactions with others, or use

different, less conventional, types of gestures relative to other groups. In support of this notion, Keen (2003; 2005) proposed that some of the maladaptive behaviours demonstrated by children with ASD may be their application of gestures to regulate their interactions with others. Gernsbacher, Stevenson, Khandakar, and Goldsmith (2008) additionally stated that individuals with ASD may initiate JA as frequently as TD children, however, use atypical behaviours to do so. The possibility that different populations of children exhibit qualitative differences in their use of gestures was highlighted by research demonstrating that blind children initiate JA using a diverse range of unconventional behaviours that do not involve the use of pointing or eye gaze (Bigelow, 2003). Thus, there may be additional qualitative differences in the gesture use of individuals with ASD that have not yet been identified in the existing research.

It is also unclear whether individuals with ASD are impaired in the development of non-verbal social behaviour, or whether they are unable to apply the behaviours they acquire within the context of their social interactions with others (Hobson & Lee, 1998). The reduced use of gestures in individuals with ASD may thus reflect difficulties with another aspect of social interaction, such as the inability to incorporate multiple behaviours simultaneously (e.g., eye-contact, verbal request, and gestures).

Next, the majority of the aforementioned research studies examined the non-verbal social behaviour of individuals with ASD in a contrived experimental setting, often in dyadic interactions with an adult communicative partner. As the naturalistic social setting is considerably more complex than a contrived experimental setting for individuals with ASD, the ability to utilize non-verbal behaviours to regulate social interactions with others within a naturalistic setting, particularly in social interactions with peers, requires further investigation.

Finally, while motor skill competencies may influence an individual's ability to perform gestures, this factor was not controlled for in these studies. Impaired motor skills have frequently been reported in individuals with ASD (Huack & Dewey, 2001; Manjiviona & Prior, 1995), and include deficits in balance (Kohen-Raz, Volkmar, & Cohen, 1992), and the development of hand



dominance (Huack & Dewey, 2001). Higher frequencies of hypotonia and limb dyspraxia have also been reported in individuals with ASD relative to other communication disorders (Rapin, 1996). Baron-Cohen et al. (1996) additionally reported that a significant proportion of toddlers with ASD who were unable to point protodeclaratively (i.e., for social purposes) were also impaired in their ability to point protoimperatively (i.e., to request). This suggests that motor impairments may underlie JA deficits in these children (Gernsbacher et al., 2008). As a result, the potentially confounding effects of impairments in motor planning and execution should be controlled for in future studies.

#### *1.10.1.3 Impact of Impaired Non-Verbal Social Behaviour on Other Areas of Development*

Deficits in the development of non-verbal social behaviour may contribute to the social impairments observed in individuals with ASD (Garfin & Lord, 1986). The ability to combine multiple non-verbal cues not only increases the salience and interpretability of the communicative exchange, it reportedly increases the responsiveness of the communicative partner (Stone, Ousley, Yoder et al., 1997). This is due, in part, to the critical role of gestures in regulating and repairing social interactions. The ability to repeat, modify and change non-verbal behaviour as required throughout communicative exchanges is an important component of an individual's ability to repair communication breakdown (Brady, Steeples, & Fleming, 2005).

It is also well documented that the gesture, protodeclarative pointing, is an important component of JA behaviour. JA behaviours play an important role in a number of aspects of development, with JA skills in infancy related to subsequent language and social development (Charman, Baron-Cohen, Swettenham, Baird, Drew, & Cox, 2003; Kasari, Freeman, & Paparella, 2006; Leekam & Ramsden, 2006; Luyster, Kadlec, Carter, & Tager-Flusberg, 2008; Mundy et al., 2007; Naber et al., 2008; Siller & Sigman, 2008; Toth et al., 2006), inhibition (Dawson et al., 2002; Nichols et al., 2005), and pretend play skills (Rutherford, Young, Hepburn, & Rogers, 2007).

### *1.10.2 Imitation Skills*

The ability to imitate the actions of another person is an important skill that emerges in newborns and develops considerably over the first two years of life (Hobson & Hobson, 2008). Early imitation of body movements, vocalizations and facial expression provides a sense of communication and connectedness with social partners (Rogers, Hepburn, Stackhouse, & Wehner 2003), and serves as a learning mechanism through which new knowledge and skills are attained (Ingersoll, 2008). During the second year of life, imitation provides children with a base for social learning and helps lay the foundation for understanding the intentions and actions of others (McIntosh, Reichmann-Decker, Winkielman, & Wilbarger, 2006).

Several researchers have differentiated between involuntary and voluntary imitation (Byrne, 2005; Hamilton, 2008; McIntosh et al., 2006). Involuntary imitation is the automatic imitation or mimicking of the kinesthetic aspects of the actions and expressions of others. It is also referred to as ‘mimicry’ in the literature (Hamilton, 2008). It involves the spontaneous matching of gestures, posture and prosody between individuals (e.g., smiling in response someone else smiling). Automatic imitation facilitates communication skills (Nadel, 2002) and social interactions with others. It helps individuals to establish social rapport and affiliation, and demonstrate empathy. It also facilitates emotion recognition (Byrne, 2005; Decety & Chaminade, 2003; Lakin & Chartrand, 2003). In contrast, voluntary imitation involves imitating the goal of the action or task (Byrne, 2005). It is slow and effortful, sensitive to situational influences (McIntosh et al., 2006), and is often used as a mechanism for learning (Byrne, 2005; Hamilton, 2008). It is also referred to as ‘emulation’ in the literature (Hamilton, 2008). Research has demonstrated that, for goal-directed actions, TD children may place less importance on the kinesthetic aspects of the action movement and give priority to attaining the goal of the task. However, when the actions are meaningless, kinesthetic aspects of actions appear to be interpreted as the goal (Hamilton, 2008).

While a large number of researchers have documented that children with ASD are impaired in their ability to imitate others (Hobson & Hobson, 2008; McIntosh et al., 2006; Rogers, Bennetto,

McEvoy, & Pennington, 1996; Rogers et al., 2003; Stone, Ousley, & Littleford, 1997), the findings are mixed. In an early study, Rogers et al. (1996) matched 17 high-functioning adolescents with AD and 15 adolescents diagnosed with dyslexia and a mixture of other unspecified neurodevelopmental impairments on CA and VIQ. The adolescents participated in a series of manual and facial imitation tasks, incorporating both sequences of actions and the imitation of individual behaviours. Results showed that individuals with ASD imitated significantly fewer actions than control participants. Deficits in imitation skills were significantly more pronounced for imitating sequences than single actions. Adding meaning to a gesture facilitated the performance of individuals with AD while worsening the performance of control participants. However, the control group was ill-defined in this study, employing participants with an unspecified and diffuse range of neurodevelopmental impairments. Additionally, some of the individuals in the AD group did not meet the full criteria for AD or AsD, instead receiving a diagnosis of atypical autism. Thus, these results should be interpreted with caution, particularly with regards to inferring the specificity of an imitation deficit in individuals with ASD.

More recently, Rogers et al. (2003) examined the specificity, nature, and pervasiveness of imitation deficits in toddlers with ASD and CA- and IQ-matched toddlers with Fragile X syndrome, DD of mixed aetiology, and TD toddlers. In this study, the toddler's ability to imitate manual (e.g., clapping hands), oral-facial, and object-oriented actions (e.g., touching a box with their elbow) were assessed. Results indicated that toddlers with ASD were significantly impaired in their overall imitation abilities, oral-facial imitation, and imitation of actions with objects, relative to other groups of toddlers. Furthermore, the presence or absence of ASD-symptomatology in participants with Fragile X syndrome influenced their performance on imitation tasks. Imitation skills were strongly correlated with ASD-symptomatology for toddlers with ASD, even when controlling for developmental level. The presence of an imitation impairment in ASD was further supported in a meta-analysis by Williams, Whiten, and Singh (2004), who concluded that methodologically rigorous studies published since 1972 have consistently found an autism-specific deficit in motor

imitation. Recent neuroimaging studies have additionally identified differences in the brain activity of individuals with ASD during imitation tasks (Dapretto et al., 2005).

However, other studies have obtained mixed results, or have failed to find evidence of impaired imitation in individuals with ASD. Hobson and Hobson (2008) examined whether children with AD (Mean CA = 11.5 years) were impaired in their ability to imitate goal-directed actions and the “style” in which an action was performed, relative to non-autistic learning disabled, ID and DD children (Mean CA = 10.10 years). Groups were matched on CA and VMA. Results indicated that individuals with AD were unimpaired in their ability to imitate goal-directed actions, however they demonstrated a significant impairment imitating the style with which the actions were executed. McIntosh et al. (2006) examined automatic and voluntary imitation skills in 14 adolescents and adults with ASD (Mean CA = 27 years) and 14 TD adults and adolescents (Mean CA = 24 years) matched on gender, CA and verbal ability. In this study, the activation of participants’ facial muscles were measured while viewing pictures of faces depicting happy or angry emotions. While TD participants automatically mimicked the facial expressions depicted in the pictures, there was no congruent facial muscle activation for participants with ASD. However, when given an instruction to imitate the emotional expression depicted in the pictures, participants with ASD performed as well as TD participants.

In another recent study, Hamilton, Brindly, and Frith (2007) examined goal-directed imitation in 25 children with ASD (Mean CA = 8.1 years) and 31 TD children (Mean CA = 4.1 years) matched on VMA. In this task, participants were required to copy hand movements made by the experimenter that were ipsi- or contralateral to the experimenter’s body. In the goal-directed trials, the experimenter touched one of a series of dots on the table. In the control condition, no dots were present on the table; however the same action was performed by the experimenter. In the goal-directed trials, all participants demonstrated a tendency to touch the correct dot using the closest hand rather than the same hand utilized by the examiner. However, when the dots were absent from the table, all participants were more likely to imitate the action demonstrated by the

examiner. The authors concluded that children with ASD were not impaired in their ability to imitate, and their ability to identify the goal of another person's action led to imitation errors that were similar to those observed in TD children. The notion of unimpaired imitation in individuals with ASD has been supported in several other studies demonstrating that children with ASD are unimpaired in their ability to imitate facial expressions (Dapretto et al., 2005) finger movements (Williams et al., 2006), and object-directed actions (Ingersoll, Schreibman, & Tran, 2003).

#### *1.10.2.1 Summary of Research Examining Imitation in ASD*

Overall, the research literature examining the nature of imitation in ASD fails to support the notion that children with ASD demonstrate a global imitation impairment. Research findings appear to support a deficit in the automatic imitation of actions or facial expressions, and the style in which the action is executed (Hobson & Hobson, 2008; McIntosh et al., 2006; Rogers et al., 1996; 2003; Stone, Ousley, & Littleford, 1997). However individuals with ASD may be unimpaired when explicitly instructed to imitate, or on goal-directed imitation tasks that typically involve objects, and the interpretation and emulation of a goal (Hamilton, 2008; McIntosh et al., 2006). The notion that individuals with ASD are unimpaired in their ability to imitate the goal of another person's action has been supported in other research demonstrating an intact ability to imitate the intention of another person, even when the person failed to achieve their goal (Aldridge, Stone, Sweeney, & Bower, 2000; Carpenter et al., 2001).

Taken together these findings indicate that children with ASD may perform well on imitation tasks that tap into their reportedly intact understanding of means-end relationships to achieve task success. Tasks requiring the imitation of actions on objects, and imitation tasks where the meaning or intention of the task is attached, could arguably be 'solved' via emulation or the use of previously learned methods to obtain the same outcome. Conversely, the ability to imitate oral-motor facial movements and the emotional tone or quality of an action relies almost solely on social engagement and communication. Thus, differences in children with ASDs' performance on imitation tasks may be accounted for by the extent to which the task taps into the child's ability to

engage socially with the examiner, and eliminates the possibility of achieving task success via an alternative route (e.g., emulation).

Southgate and colleagues (Southgate, Gergely, & Csibra, 2008; Southgate & Hamilton, 2008) proposed that the imitation deficits reported in individuals with ASD do not reflect an inability to imitate, but rather difficulties identifying and responding to the relevant cues that facilitate knowing what and when to imitate. Social and communicative cues serve to modulate imitation in TD individuals (Brugger, Lariviere, Mumme, & Bushnell, 2007; Southgate, Gergely, & Csibra, 2008), however difficulties identifying and responding to these cues might account for the excess imitation (e.g., echolalia or echopraxia) demonstrated by individuals with ASD in some situations, and the absence of appropriate imitation in others (Hamilton, 2008).

#### *1.10.2.2 Limitations of Research Examining Imitation in ASD*

Contradictory results in the literature examining imitation in individuals with ASD may reflect the heterogeneity of the procedures used and an absence of a clear definition regarding the type of imitation explored (e.g., spontaneous versus induced; symbolic versus concrete; immediate versus deferred; simple versus complex; imitation of actions versus goals). Hamilton (2008) proposed that imitation is a multifaceted construct, with different types of imitation tasks engaging different cognitive and neural systems (Gallagher & Frith, 2004; Hamilton et al., 2007). As a result, the types of behaviours children with ASD can and cannot imitate, the related neurological processes, and the conditions under which they will imitate such behaviours remain unclear.

Many studies in this area have also failed to account for the influences of extraneous factors such as motivation, task understanding, perceptual deficits, memory, and motor skills on task performance (Bennetto, Pennington, & Rogers, 1996; Charman & Baron-Cohen, 1994; Huack & Dewey, 2001; Steele, Minshew, Luna, & Sweeney, 2007; Stone, Ousley, & Yodar et al., 1997; Stone, Ousley, & Littleford, 1997). Other studies employed small group sizes (McDonough, Stahmer, Schreibman, & Thompson, 1997), or failed to confirm the diagnosis of participants (Charman & Baron-Cohen, 1994). Researchers have also suggested that imitation deficits in

individuals with ASD are more severe for children with lower cognitive abilities (Receveur et al., 2005), however groups were not matched on cognitive ability in many of these studies.

Finally, studies examining imitation in children with ASD have generally focused on induced imitation in an experimental setting, rather than spontaneous imitation in a social context. As a result, the spontaneous imitation of children with ASD in the natural social setting is poorly understood. Previous research suggests that the imitation of children with ASD may differ in the type, nature and social function, relative to TD children. As a result of these differences, the imitation skills of children with ASD may not be easily observed in the experimental setting. For example, parents of children with ASD sometimes report that their children demonstrate 'delayed imitation' whereby they imitate actions hours after they were first performed, when they were not asked to do so. The presence of echolalia and echopraxia further supports this notion. Thus, rather than focusing on the presence or absence of imitative behaviours in a contrived, experimental setting, future research should aim to understand differences in the nature and function of imitation demonstrated by children with ASD, relative to other groups of individuals.

#### *1.10.2.3 Relationship between Imitation and other Areas of Development*

Previous research has consistently demonstrated that imitation skills are important for the development of both early and later language abilities in children with AD (Charman et al., 2000, 2003; Stone, Ousley, & Littleford, 1997; Stone & Yoder, 2001). After controlling for early language ability, Stone and Yoder (2001) reported that motor imitation at 2 years of age was predictive of expressive language skills at 4 years of age. Similarly, Charman et al. (2003) reported that the imitation of actions on objects at 20 months of age was positively associated with receptive language skills at 42 months of age. More recently, Toth et al. (2006) reported that immediate imitation skills predicted language ability at age 3 to 4 years, and deferred imitation was predictive of the rate of development of communication skills for children with AD aged between 4 and 6 years of age. Conversely, Rogers et al. (2003) failed to establish a relationship between oral motor, object, or body imitation and concurrent language development in toddlers with AD. Discrepant

findings may suggest that the relationship between imitation and language development is contingent upon the type of imitation being assessed (e.g., oral-motor vs. imitation with objects), and / or is mediated by other factors (Ingersoll, 2008).

Previous research studies have also established a relationship between imitation and the development of play skills in young children with AD. Stone, Ousley, and Littleford (1997) found a significant correlation between the ability to imitate actions with objects at 2 years of age and play skills at 3 years of age. Ingersoll and Schreibman (2006) reported that teaching object imitation skills to young children with AD led to significant increases in their spontaneous pretend play skills. Taken together, these findings indicate that imitating functional and symbolic actions helps facilitate the development of play skills. However, Rogers et al. (2003) failed to find a relationship between the imitation of actions with objects and concurrent play skills in children with ASD, after controlling for developmental age. Despite this, a significant relationship between object imitation and play skills was reported for DD children. These findings indicate that the relationship between imitation and play skills may be mediated by other variables, such as the developmental level of participants.

Imitation deficits have also been associated with impaired peer play due to the role of imitation with toys in the social play of young children (Ingersoll, 2008). Researchers have further proposed that imitation skills help establish shared experiences, and a sense of mutual connectedness between social partners. They are also critical for the development of communication skills, social play and peer relationships (Brown & Whiten, 2000; Meltzoff, 2005). Relationships between imitation and social responsivity (McDuffie et al., 2007; Rogers et al., 2003), and the development of perspective taking skills (Perra et al., 2008) have additionally been established.

Finally, a relationship between early imitation skills and the development of JA has been well established in the literature (Rogers et al., 2003). Carpenter et al. (2002) reported that object imitation skills preceded the development of JA in preschool-aged children with AD. After



controlling for developmental age, Rogers et al. (2003) found that both oral imitation and imitation with objects was associated with JA in toddlers with AD. Finally, Ingersoll and Schreibman (2006) reported increases in JA skills after teaching young children with AD to imitate actions with objects.

Taken together, the aforementioned research supports the notion that imitation skills are important for the development of play, language and social communication skills in children with ASD. However, it is unclear whether imitation skills directly impact on these areas of development or whether these relationships are mediated by factors such as the severity of autistic symptomatology (Rogers et al., 2003) or the developmental level of participants (Rogers et al., 2003). More research employing more consistent procedures, as well as a clearer definition regarding the type of imitation being explored is necessary in order to establish clearer relationships in this area.

### *1.10.3 Social Interactions*

One of the prominent social deficits observed in children with ASD pertains to the extent to which they engage in social interactions with others (Adamson, McArthur, Markov, Dunbar, & Bakeman, 2001; Charman & Baron-Cohen, 2006; Jackson et al., 2003; Jones & Schwartz, 2009; Leekam & Ramsden, 2006; Marans, Rubin, & Laurent, 2005). Several researchers have demonstrated that individuals with ASD are significantly less likely to initiate or respond to attention, play, and conversational bids than TD children or children with an ID (Doussard-Roosevelt, Joe, Bazhenova, & Porges, 2003; Jackson et al., 2003; Jahr, Eikeseth, Eldevik, & Aase, 2007; Jones & Schwartz, 2009; Marans et al., 2005; Rubin & Lennon, 2004). Other researchers have demonstrated that the social interactions of individuals with ASD frequently lack mutual engagement (Leekam & Ramsden, 2006), are at a lower developmental level than TD children (Carter et al., 2005; Huack, Fein, Waterhouse, & Feinstein, 1995; Loncola & Graig-Unkefer, 2005) primarily function to serve their needs rather than for the purposes of social engagement

(Bauminger et al., 2003; Chiang et al., 2008; Ruble, 2001), and lack temporal synchrony (Boucher, 2003; Kwakye, Foss-Feig, Cascio, Stone, & Wallace, 2011; Wimpory, Nicholas, & Nash, 2002).

Jackson et al. (2003) examined the sustained interactions and responsivity to social bids in 19 children with ASD (Mean CA = 9.6 years) and 14 CA- and MA-matched ID children (Mean CA = 9.2 years) during periods of lunch and free-play in the school setting. Results indicated that children with ASD initiated interactions with peers at a significantly lower frequency, and were less likely to engage in sustained play with peers than children with an ID. They also produced fewer positive responses overall and more 'no-responses' to the social bids of others. Using an older group of participants, Bauminger et al. (2003) examined the social interactions of 18 high-functioning children with ASD (Mean CA = 11.0 years) and 17 TD children (Mean CA = 11.5 years) during unstructured social interactions in the school setting. Participants were matched on CA, IQ, gender, and maternal education. Children with ASD initiated social interactions and responded to peers' social bids at approximately half the rate of TD children. They were also impaired in their ability to demonstrate combined and complex social behaviours (such as smiling and establishing eye-contact), and were significantly more likely to engage in functional communication than TD children. Finally, Jahr et al. (2007) reported that 23 children with ASD (Mean CA = 5.3 years) engaged in sustained social interactions with peers significantly less frequently than 17 CA-matched TD children (Mean CA = 4.10 years).

Other researchers have demonstrated that individuals with ASD are significantly impaired in initiating conversations, and in providing topic relevant comments and questions in response to the conversational bids of others (Adamson et al., 2001; Doussard-Roosevelt et al., 2003; Marans et al., 2005; Rubin & Lennon, 2004). Jones and Schwartz (2009) examined the communication skills of 20 high-functioning children with ASD (Mean CA = 5.7 years) and 10 TD children (Mean CA = 5.2 years) engaged in typical dinner time conversation with their families. Results indicated that children with ASD initiated conversation significantly less frequently than TD children. They also offered fewer personal narratives, comments or questions to sustain the interaction, made

fewer conversational exchanges, and were significantly less likely to respond to the questions and comments of family members relative to TD children.

Finally, social timing deficits have been documented in individuals with ASD (Boucher, 2003; Kwakye et al., 2011; Wimpory et al., 2002). Synchronous timing in social interactions is of critical importance to social and communicative development in TD infants and children, and has been linked to the development of language, JA, and mental-state understanding (Boucher, 2003; Trevarthen & Aitken, 2001; Wimpory, Hobson, Williams, & Nash, 2000). Several theorists have postulated that temporal deficits are central to the social and communication impairments observed in individuals with ASD (Boucher, 2003; Kwakye et al., 2011; Wimpory et al., 2002).

Asynchronous timing impedes the establishment of mutual, social connectedness, and results in fragmented representations of situations and experiences that lack associations between social cues, events, and outcomes. The notion of impaired social timing in ASD has been supported in research demonstrating impaired interactive timing in preverbal, non-verbal and verbal interactions in infants and children with ASD (Boucher, 2003; Wimpory et al., 2000), as well as in other aspects of functioning such as attention (Courchesne et al., 1994; Landry & Bryson, 2004), and information processing (Kwakye et al., 2011; Szelag, Kowalska, Galkowski, & Poppel, 2004).

#### *1.10.3.1 Summary of Research Examining Social Interactions in ASD*

Research has consistently demonstrated that the social interactions of individuals with ASD are quantitatively and qualitatively different from TD and DD individuals. Children with ASD initiate social interactions less frequently, are significantly less likely to respond to the social initiations of others, and engage in social interaction for significantly shorter durations than TD and DD children. Qualitatively, while many of the behaviours observed in TD children involve combined and complex social behaviours, children with ASD consistently demonstrate difficulties initiating communicative, complex, positive social behaviours (e.g., establishing eye-contact and smiling). Evidence also suggests that children with ASD also use lower level behaviours (e.g.,

functional communication) to initiate interaction, and lack temporal synchrony in their social and communicative interactions (Boucher, 2003; Kwakye et al., 2011; Wimpory et al., 2002).

The notion that individuals with ASD engage in social interactions for non-social functions more frequently than other groups of individuals has been supported in several research studies (Bauminger et al., 2003; Chiang et al., 2008; Ruble, 2001). A relative strength in engaging in social behaviour for the purpose of regulating or requesting (Ruble, 2001; Wetherby, 1986), and a pronounced weakness in communicating or interacting for social purposes (Wetherby, Prizant, & Hutchinson, 1998) has been consistently documented.

Research has also consistently reported that children with ASD are more likely to initiate social interactions with adults than peers (Anderson, Moore, Godfrey, & Fletcher-Flinn, 2004; Huack et al., 1995; Ingram, Mayes, Troxell, & Calhoun, 2007; Koegel, Koegel, Frea, & Freedden, 2001), and respond to the social bids of adults (Ingram et al., 2007; Jackson et al., 2003; Koegel et al., 2001). Jackson et al. (2003) proposed that interactions with adults differ from those with peers due to their functional rather than purely social nature. Consistent with this, Anderson et al. (2004) reported that 83 to 100% of the social interactions that kindergarten-aged children with ASD engaged in, involved adults. They further reported that the majority of the aforementioned interactions were for the purpose of seeking assistance, or were the result of unsolicited assistance-giving by adults.

#### *1.10.3.2 Limitations of Research Examining Social Interactions in ASD*

The majority of previous research studies examining the social interactions of individuals with ASD have failed to sufficiently document the form, function and quality of their social initiations and responses (Jones & Schwartz, 2009; Lord & Magill-Evans, 1995). As a result, it is unclear whether the social initiations and of children with ASD are positive or negative in nature (Lord & Magill-Evans, 1995), or whether the responses of children with ASD serve to terminate or sustain the social interaction (Jones & Schwartz, 2009). It is possible that children with ASD who predominantly initiate social interactions using negative (e.g., taking the toy of a peer) or low level

social behaviours (e.g., using a soft voice without first gaining the attention of their listener) fail to receive positive responses from their peers, thereby decreasing the frequency with which they initiate future social interactions with peers. The importance of the quality of social responses and initiations was highlighted by Chang (2008), who examined the nature of communicative spontaneity in 32 children with ASD (Mean CA = 7.9 years). Participants were videotaped for two hours in the school setting while participating in a variety of structured and unstructured activities. The communicative partner (e.g., peer, teacher), and the form (e.g., vocalization, non-verbal etc), function (e.g., request, comment etc) and consequence (e.g., no response, delivered etc) of the communicative acts were recorded. Results indicated that participants with ASD initiated communication for requesting and rejecting functions significantly more frequently than other, more social, communicative purposes. Results also indicated that a high proportion of the communicative acts from individuals with ASD were denied or met with no response from their communicative partners, indicating that these acts may be contextually inappropriate.

Related to this, it is unclear from the available research whether individuals with ASD use alternative behaviours to TD children that may be inappropriate or ineffective to engage in social interactions with others, but may stem from underlying social motivation. Such behaviours may include those behaviours typically considered non-communicative and unintentional, such as stereotyped utterances (e.g., echolalia). In support of this notion, previous research has demonstrated that echolalia may function to request, regulate, protest, declare, affirm or self-regulate for individuals with ASD (Wetherby, 1986). The form, function, and quality of the social initiations and responses of individuals with ASD thus requires further study in order to fully understand the exact nature of the deficits and atypicalities of these behaviours in individuals with ASD.

Finally, most studies examining the social behaviour of children with ASD failed to account for the quality of the social initiations from peers (Ruble, 2001). It is possible that children with ASD are less likely to respond to negative or inappropriate social bids from their peers.

Studies in this area should thus endeavour to classify the types of social bids made by the peers of children with ASD in order to determine the rate at which children with ASD respond to positive versus negative social bids.

#### *1.10.4 Social Play Skills*

Parten (1932) categorized children's social play into six categories, each moving towards greater involvement and cooperation with peers. TD children move from unoccupied play, whereby they are not involved in any particular activity, to solitary play. Solitary play refers to the child playing alone with little to no interest in other children or what they are doing. Following this, children's play becomes more socially oriented, and they begin to engage in onlooker play. In onlooker play, children watch other children playing without becoming actively involved. At approximately 2 years of age, children begin to play alongside or in 'parallel' with other children. Parallel play involves the use of similar toys without any social interaction. At approximately 3 years of age, children begin to engage in similar (but not identical) activities. This is known as associative play, and involves children sharing toys and interacting with each other, with no specific organization of activities. Finally, cooperative play refers to the child's involvement in a group with a specific purpose (e.g., playing a game). This type of play involves organization and often has defined roles within the group.

Research has consistently documented impaired social play skills in individuals with ASD (Anderson et al., 2004; Holmes & Willoughby, 2005; Ingram et al., 2007; Jahr et al., 2007; Sigman & Ruskin, 1999; Watson, Baranek, & DiLavore, 2003). Anderson et al. (2004) examined the social play skills of ten, 3- to 7-year-old children with ASD. Control subjects were TD children who were in close proximity to the 'target' child for the majority of the play intervals. Observations were conducted on two separate occasions approximately four months apart. For each 10-second interval, the dominant category of play according to The Parten Scale (Ballard, 1981) was allocated a score ranging from 1 (unoccupied) to 6 (cooperative play). The resulting scores for each interval

were calculated. Results indicated that children with ASD engaged in significantly less sophisticated social play than TD children. They rarely participated in group play, and participated in parallel and solitary play for the majority of the time. The results further revealed that the observed play deficits were consistent across children in both kindergarten and school settings.

More recently, Macintosh and Dissanayake (2006) examined the social behaviour of 4- to 10-year-old children with HFA (Mean CA = 8.1 years), AsD (Mean CA = 8.0 years) and TD children (Mean CA = 7.01 years) engaged in free-play with peers in the school or preschool setting. Groups were matched on CA and MA. In this study, children's social play skills, non-verbal, and verbal interactions were scored. The number of participants in the social interaction, the direction of the interaction (e.g., initiation, response or part of ongoing activity), and the quality of the social interactions (e.g., negative, positive or neutral) were also recorded. Results indicated that TD children spent significantly less time unoccupied than children with HFA or AsD, and significantly more time engaged in social play than children with HFA. While children with AsD spent more time engaged in verbal interaction than participants with HFA, there were no group differences between children with HFA and AsD on social play variables. Further analyses revealed that TD children spent more time engaged in social interaction with three or more peers simultaneously than either clinical group, while children with HFA or AsD spent significantly more time alone than TD children. While participants with AsD made more social bids than participants with HFA, both participants with AsD and HFA spent significantly less time engaged in ongoing social interactions than TD children.

Finally, Jahr et al. (2007) observed the unstructured social interaction and play skills of 23 children with ASD (Mean CA = 5.3 years) and 17 CA-matched TD children (Mean CA = 4.10). Participants with ASD were further subdivided on the basis of their cognitive functioning. There were 12 high-functioning participants ( $IQ \geq 70$ ; Mean CA = 5.3 years) and 11 participants with lower cognitive abilities ( $IQ 50-69$ ; Mean CA = 5.3 years). In this study, the frequency (i.e., presence / absence) and duration of participants' parallel play, cooperative play, and verbal

interaction with peers was examined in the preschool or school setting over a period of 10 days. The latency to engage in social interaction from the beginning of the observation period was also examined. Results indicated that while there were no group differences in the latency to engage in social interaction, TD children engaged in social interaction significantly more frequently than both groups of participants with ASD. While more high-functioning participants with ASD engaged in sustained social interactions than low-functioning participants, this difference failed to reach statistical significance. CA was not related to the frequency or latency to engage in social interaction for participants with ASD, however, older TD children engaged in a higher frequency of social interactions.

#### *1.10.4.1 Summary of Research Examining Social Play Skills in ASD*

In summary, research examining the social play skills of individuals with ASD has consistently supported the notion that they are impaired in their ability to engage in social play with peers. Children with ASD spend more time engaged in solitary, isolated or onlooker play, show social play skills of a lower developmental level relative to their same-aged peers, and are significantly less likely to engage in sustained associative or cooperative play with their peers (Anderson et al., 2004; Holmes & Willoughby, 2005; Ingram et al., 2007; Jahr et al., 2007; Sigman & Ruskin, 1999; Watson, Baranek, & DiLavore, 2003). Deficits in the social play skills of children with ASD are stable across settings (Holmes & Willoughby, 2005).

#### *1.10.4.2 Limitations of Research Examining Social Play Skills in ASD*

Research literature examining the social play skills of children with ASD lacks consensus regarding the descriptions of play behaviour and social interactions investigated. In several studies (Jahr, Eledevik, & Eikeseth, 2000; McGrath, Bosch, Sullivan, & Fuqua, 2003), social behaviour was defined within the context of play activities. It is well documented that toy play is significantly impaired in children with ASD. Research specifically suggests that the toy play of children with ASD is less functional, varied, integrated, socially oriented, and is of a lower developmental level than that of TD children (Rowland & Schweigert, 2009; Williams, 2003, Williams, Reddy, &



Costall, 2001). The failure to separate and distinguish between toy play (i.e., sensorimotor, functional, and symbolic play) and social play (i.e., onlooker, parallel, associative and cooperative play) makes it difficult to decipher the extent to which observed deficits in children with ASD stem from specific difficulties with the social or imaginative aspects of play (Pierce-Jordan & Lifter, 2005). As these skill areas are often classified and examined as a single construct, it is also unclear whether a relationship exists between them.

In addition, while many studies examined the presence of social play skills in children with ASD, they failed to examine the quality of their social play skills. As a result, the extent to which individuals with ASD generate strategies, ideas and roles to contribute to, and sustain more complex social play, remains unclear.

#### *1.10.5 Additional Factors Impacting on Social Behaviour in ASD*

Additional factors that may impact on the social behaviour of individuals with ASD include their cognitive skills, peer group composition, and the concurrent social or cognitive demands of the social situation.

##### *1.10.5.1 Cognitive Functioning*

Several researchers have proposed that high-functioning children with ASD display a greater capacity for social interactions than their lower functioning counterparts by using their relatively high cognitive abilities (Bauminger, 2002; Huack et al., 1995; Sigman & Ruskin, 1999). This subgroup of children is reportedly able to engage in more complex social interactions, and is more likely to initiate and respond to peer interactions. They also show greater social-emotional expressiveness and responsiveness than other, lower functioning, children with ASD (Capps, Sigman, & Yirmiya, 1995; Sigman & Ruskin, 1999).

However, other researchers have failed to find a relationship between cognitive abilities and social functioning in children with ASD (Ingram et al., 2007; Jahr et al., 2007). Several researchers have reported that the social behaviour of children with ASD is qualitatively impaired for any mental age, with high-functioning children with ASD experiencing a significant degree of

social isolation, higher rates of socially inappropriate behaviour, and lower rates of reciprocal social interaction and social play with peers. They also demonstrate significant ‘failure’ in their social relationships with peers, and show substantial discrepancies between their knowledge (i.e., what they understand about social situations) and behaviour (i.e., what they do in social situations) relative to non-ASD, intellectually disabled peers (Ingram et al., 2007; Jahr et al., 2007; Ozonoff & Miller, 1995; Sigman & Ruskin, 1999). Finally, while some high-functioning children with ASD demonstrate an ability to understand another person’s perspective in an experimental setting, they fail to apply this understanding in their everyday interactions with peers (Ozonoff & Miller, 1995; Sigman & Ruskin, 1999).

Thus, while several research studies support the notion that high-functioning children with ASD exhibit superior social behaviour skills relative to lower functioning children with ASD, higher cognitive abilities are not sufficient to remediate the significant social impairments evident in children with ASD relative to TD and ID comparison children.

#### *1.10.5.2 Composition of Peer Group*

Previous research has demonstrated that the composition of the peer group significantly impacts on the extent to which children with ASD initiate and respond to the social bids of their peers (Bauminger et al., 2003; 2008; Lord & Hopkins, 1986; Lord & Magill-Evans, 1995; Sigman & Ruskin, 1999). Children with ASD are more likely to engage in reciprocal social interactions, demonstrate higher levels of complex, positive social behaviour, and exhibit lower levels of non-social play in the presence of TD peers (Bauminger et al., 2003; 2008; Lord & Magill-Evans, 1995; Sigman & Ruskin, 1999). They are also significantly more likely to direct social initiations and responses toward TD, than non-TD peers (Bauminger et al., 2003). Bauminger et al. (2008) additionally reported that dyadic friendships between the children with ASD and TD children were more secure, mutually responsive, goal oriented, positive, fun, and engaged in more complex social play than friendship dyads between children with ASD and children with other disabilities.

Improvements in the social behaviour of children with ASD when interacting with TD peers may be attributed to TD children initiating ‘higher quality’ interactions than other groups of children, and providing children with ASD with more opportunities for positive social interactions (Bauminger et al., 2008). Related to this, researchers have suggested that children with ASD are more likely to respond to higher quality social initiations from their peers (Lord & Hopkins, 1986).

#### *1.10.5.3 Concurrent Activities at the Time of Assessment*

Other researchers have reported that the degree of social impairment observed in children with ASD is related to the concurrent demands of the task or social situation. Research examining dual processing has reported that children with ASD demonstrate difficulties in engaging in two tasks simultaneously (Casey, Gordon, Mannheim, & Rumsey, 1993; Plaisted, Swettenham, & Rees, 1999). Performance on one task decreases when attentional resources are allocated to another task (Casey et al., 1993; Plaisted et al., 1999). It is also well documented that difficulties with tasks requiring dual processing increase when one of the tasks being undertaken is not ‘automatic’ (Plaisted et al., 1999). This is consistent with the concept of “allocation of resources” which proposes that demanding tasks require more cognitive resources than less complex tasks (Pierce-Jordan & Lifter, 2005). As social behaviour is difficult for children with ASD, it most likely requires the conscious application of cognitive resources.

In support of this notion, children with ASD are less likely to demonstrate combined social behaviours, such as declarative gestures with eye-contact (Bauminger et al., 2003; Ruble, 2001). Children with ASD are also less likely to demonstrate social behaviour when engaged in an ‘emerging’ play activity (Malone, Stoneman, & Langone, 1994; Pierce-Jordan & Lifter, 2005). In a study examining the relationship between social interaction and play skills, Pierce-Jordan and Lifter (2005) reported that the coordinated social interactions of children with ASD, PDD and TD children decreased when they were engaged in play that was developmentally difficult (e.g., symbolic play). Furthermore, when participating in developmentally difficult play, children with ASD were more likely to engage in solitary play than other groups of children. Pierce-Jordan and

Lifter (2005) concluded that as social and play behaviours compete for the same cognitive resources, it is difficult for children to engage in social and play actions simultaneously when one of the tasks (e.g., the play activity) is difficult for them. This finding was supported by Malone et al. (1994) who reported that more complex play skills were demonstrated by children with ASD in environments with limited social demands.

### 1.11 Chapter Summary and Conclusions

In this chapter, the diagnostic criteria and course, prevalence rates, aetiology, co-morbid diagnosis, prognosis and unresolved issues pertaining to ASD were overviewed. Due to the importance of social deficits in diagnosing and understanding ASD, key areas of social impairments were reviewed in detail; including non-verbal social behaviour, imitation skills, social interactions and social play skills. A review of the literature demonstrated that individuals with ASD are significantly impaired in all areas of social behaviour, relative to TD and DD individuals. They use significantly less social behaviour for purely social or communicative purposes, and display a more limited range, and less complex combinations of social behaviour. They also exhibit social behaviour of a lower developmental level than other groups of children. Social behaviours for requesting or rejecting functions, social interactions with adults, and social assessment tasks that could be emulated or solved by other cognitive means are relatively unimpaired in individuals with ASD. The research further indicated that the social behaviour of individuals with ASD may be influenced by their cognitive abilities, the composition of their peer group, and concurrent activities at the time of the social assessment. However, the extent to which individuals with ASD use atypical forms of social behaviour, or fail to demonstrate learned social behaviours due to difficulties reading the social cues that modulate when and how to apply the behaviour in the social setting, remains unclear.

## CHAPTER 2: PROMINENT PSYCHOLOGICAL THEORIES OF ASD

### 2.1 Chapter Overview

In this chapter, the three prominent psychological theories of ASD are described: Weak Central Coherence, Executive Functions, and Theory of Mind. The theories are briefly overviewed, and evidence supporting the theories is presented. Limitations of the theories are then described.

### 2.2 Overview of the Prominent Psychological Theories of ASD

Despite the general acceptance of a biological basis for ASD, there is still no consensus regarding the cognitive model that best explains ASD symptomatology (Volkmar, Lord, Bailey, & Klin, 2004). A number of theories have been proposed to account for some or all of the deficits observed in individuals with ASD, and include the Weak Central Coherence (WCC; Frith & Happé, 1994; Happé & Frith, 2006; Hill & Frith, 2003; O'Connor & Kirk, 2008), Executive Functions (EF; Geurts et al., 2004; Ozonoff & Strayer, 1997; 2001; Ozonoff et al., 2004; Russell, Jarrold, & Hood, 1999; Verté, Geurts, Roeyers, Oosterlaan, & Sergeant, 2006; see Hill, 2004 for a recent review), Theory of Mind (ToM; Baron-Cohen, Leslie, & Frith, 1985; Happé, 1995; Schlinger, 2009), Empathizing-Systemizing (Baron-Cohen, 2009), and broken mirror (Iacoboni & Dapretto, 2006; Ramachandran & Oberman, 2006; Williams, Whiten, Suddendorf, & Perrett, 2001) theories. As is beyond the scope of the current thesis to review all of the psychological theories proposed to account for ASD, the present discussion will be limited to three prevalent psychological theories; WCC, ToM and EF.

### 2.3 Weak Central Coherence

Typically developing individuals show a bias for global information processing. They process information within its context, extract meaning, grasp abstract relationships between stimuli, and see the coherent 'whole' before the details (Frick, Colombo, & Ryther-Allen, 2000;

Frith, 2003). In contrast, the WCC hypothesis proposes that ASD is characterized by a cognitive style that is biased towards processing information at a detail-focused, featural, or local level (Brosnan, Scott, Fox, & Pye, 2004; Frith & Happé, 1994; Happé & Frith, 2006; Hill & Frith, 2003; O'Connor & Kirk, 2008). As a result, the details of the stimulus, rather than the global whole are conceptualized. Frequently observed behaviours that may be related to a featural processing bias in individuals with ASD include narrow interests, poor generalization, a preoccupation with parts of objects, a tendency to attend to irrelevant details, and difficulties taking account of the context in regulating behaviour (Happé & Frith, 2006; Mottron, Dawson, Soulieres, Hubert, & Burack, 2006). Happé and Frith (2006) additionally reported that perceptual atypicalities, such as hypersensitivity to sensory stimuli, may stem from processing stimuli out of context.

Several lines of evidence support a local information processing bias in individuals with ASD (for a recent review, see Happé & Frith, 2006). First, it is thought that the global features of a stimulus interfere with the perceptual isolation of its component parts. Thus, if individuals with ASD fail to perceive the global aspects of the stimulus, they should exhibit superior performance on tasks requiring segmentation skills, and the ability to attend to and process local level details (Mann & Walker, 2003). This notion has been supported in several studies. Individuals with ASD are faster and more accurate than other groups of individuals on tasks requiring the segmentation of a design into its constituent parts (Happé, 1999; Shah & Frith, 1993), the detection of figures embedded within larger drawings (Jolliffe & Baron-Cohen, 1997; Morgan, Maybery, & Durkin, 2003; Mottron, Burack, Iarocci, Belleville, & Enns, 2003; Shah & Frith, 1993), and the detection of a target stimulus within a complex visual search array (Jarrod, Gilchrist, & Bender, 2005; O'Riordan & Plaisted, 2001; O'Riordan, Plaisted, Driver, & Baron-Cohen, 2001; Plaisted, O'Riordan, & Baron-Cohen, 1998a). Several researchers have also documented a local processing bias in individuals with ASD using the Navon task (Navon, 1977). In this task, participants are shown a large letter comprised of a series of repetitions of a small letter, and asked to identify either the global (large) or local (small) letters of the Navon letter. Figures (e.g., 1, 2) may also be

used for this task. Several studies have reported that individual with ASD show an enhanced ability to recognize the local elements of the stimulus at the expense of the global letter (Behrmann, Avidan et al., 2006; Mottron & Belleville, 1993; Plaisted, Swettenham, & Rees, 1999).

In an early study, Plaisted et al. (1998a) reported that children with ASD (Mean CA = 8.9 years) were superior to CA-and language-matched TD children (Mean CA =7.10 years) on a conjunctive visual search task. Similarly, O’Riordan et al. (2001) examined the visual search abilities of 6- to 10-year-old children with ASD and TD children matched on CA and cognitive ability. Children with ASD demonstrated a superior performance on difficult visual search tasks, showing faster reaction times and search rates than TD children. More recently Behrmann, Avidan et al. (2006) examined the perceptual processing skills of 14 adults with HFA aged between 19 and 53 years, and 27 TD adults using a computerized Navon task. Two TD participants were matched with each participant with HFA on gender, CA, and level of education. In contrast to TD adults, participants with HFA were faster at recognizing the local than global features of the stimulus, supporting the notion of a local information processing bias in HFA.

Second, evidence of a local-processing bias in ASD has been obtained from research demonstrating that individuals with ASD are less prone to geometric visual illusions, such as the Muller-Lyer illusion, and contour illusions than TD and learning disabled individuals (Happé, 1996; however see Milne & Scope, 2008; Ropar & Mitchell, 1999; 2001). Happé (1996) reported that 7- and 8-year-old children with AD made significantly more accurate judgments about illusions than TD and learning disabled children. According to Happé (1996) this stemmed from their failure to integrate the overall context of the figures, thus allowing their attention to focus on the target form without interference from the surrounding context.

Third, in contrast to non-autistic individuals, individuals with ASD show a relative impairment taking account of the context, and integrating details of information into a coherent whole. They are less able to arrange sentences coherently, make context-appropriate inferences in short stories, and are overly-literal in their interpretation of verbal and written language (Minshew,

Goldstein, & Siegal, 1995). They also demonstrate an impaired ability to integrate face and voice expressions (Hall, Szechtman, & Nahmias, 2003; O'Connor, 2007), and fragments of objects (Jolliffe & Baron-Cohen, 2000; 2001). Jolliffe and Baron-Cohen (2001) presented 17 with adults with HFA, 17 adults with AsD, and 17 TD adults, matched on CA, IQ, gender, and handedness with a modified version of the Hooper Visual Organisation Test (Hooper, 1983). This task was comprised of two experimental conditions. In the first condition, participants were presented with a series of line drawings depicting common objects that had been cut in several pieces. The pieces were presented to participants in a puzzle-like format. Participants were required to identify the object by mentally integrating the fragments depicted in the pieces. In the second condition, participants were presented with a picture depicting a single element of a common object and were required to identify the object. Participants with HFASD were significantly impaired in their ability to integrate the visual elements of the fragmented objects, however, they did not differ from TD participants in their ability to identify an object from a single part.

Similarly, several studies have reported that participants with ASD recognize coherent motion at a higher threshold than TD individuals (Bertone, Mottron, Jelenic, & Faubert, 2003; Milne et al., 2002; Pellicano, Gibson, Maybery, Durkin, & Badcock, 2005). Milne et al. (2002) presented children with AD (Mean CA = 11.8) and CA-and NVIQ (non-verbal IQ)-matched TD children (Mean CA = 11.7 years) with a visual stimulus comprised of randomly moving dots (i.e., random dot kinematogram). Participants were required to identify the direction of coherent motion within the dots. The motion coherence threshold was measured by determining the lowest proportion of dots needed to move together for the child to correctly identify the direction of the coherent movement. Results indicated that participants with AD required a significantly higher number of dots moving coherently to correctly perceive the direction of coherent movement than did TD children, suggesting that these participants were less-proficient at conceptualising the individual moving dots as a coherent whole.



Finally, evidence of a local-processing bias in ASD has been derived from studies of face processing (Deruelle, Rondan, Gepner, & Tardif, 2004). While face recognition requires both the perception of the individual features of the face (e.g., eyes, mouth) and the configuration (i.e., the relationship) between them (Maurer, Le Grand, & Mondloch, 2002), the ability to perceive the face as a whole is thought to underlie face recognition. Numerous research studies have demonstrated that individuals with ASD show a bias for processing the featural rather than configural aspects of faces. They show impaired facial recognition skills (Barton et al., 2004; Klin et al., 1999; Teunisse & De Gelder, 2003), and a preference for matching the local rather than configural aspects of faces and face-like geometric stimuli (Rondan & Deruelle, 2007). Furthermore, while TD individuals show a decline in performance when configural processing is disrupted and the use of feature-based recognition strategies are necessary, individuals with ASD do not show a decrement in their performance on face-inversion tasks, or on tasks in which the parts of faces are misaligned (Teunisse & de Gelder, 2003).

Other evidence supporting the notion of enhanced local processing, and a relative impairment in the global processing of faces has been derived from studies of spatial frequency (Deruelle et al., 2004; Goffaux, Hault, Michel, Vuong, & Rossion, 2005; Goffaux & Rossion, 2006). When low-spatial frequencies are used, the face is blurred and the global features of the face are portrayed. Conversely, high spatial frequencies increase the contrasts of the face, thus enhancing the salience of the local facial features (Deruelle et al., 2004; Goffaux et al., 2005; Goffaux & Rossion, 2006). Deruelle et al. (2004) reported that children with ASD (Mean CA = 9.3 years) were significantly better at facial recognition when high, rather than low spatial frequencies, were used. However, the opposite pattern was observed for CA (Mean CA = 9.5 years) and VMA-matched (Mean CA = 6.6 years) TD children, who demonstrated better facial identity recognition skills from low than high spatial frequencies. These findings indicate that while individuals with ASD are more proficient at processing the local than configural features of faces, TD individuals preferentially attend to configural facial information. The notion of a local face-processing bias in

individuals with ASD was supported in a more recent study by Katsyri, Saalasti, Tiippana, von Wendt, and Sams (2008), who examined the ability of 20 adults with AsD (Mean CA = 32.0 years) and CA-and-gender-matched TD adults (Mean CA = 31.0 years) to recognize basic facial emotions (e.g., anger, fear, happiness, disgust) presented at low spatial frequencies. Results indicated that while participants with AsD were unimpaired in their ability to identify emotions depicted on non-filtered faces, they were significantly less accurate in their identification of emotions presented at low spatial frequencies, relative to TD participants. The authors concluded that individuals with AsD are impaired in their ability to process faces at a global level.

Finally, studies using functional magnetic resonance imaging (fMRI) have demonstrated that individuals with ASD exhibit a pattern of brain activity during face perception tasks that is similar to the pattern typically elicited when processing objects at a featural level (Pierce, Muller, Ambrose, Allen, & Courchesne, 2001; Schultz et al., 2000). This suggests that individuals with ASD may utilize different cognitive pathways for face recognition than TD individuals.

While studies demonstrate that individuals with ASD show atypical visual processing, the exact nature and degree of the atypicality remains unclear. Several studies examining the local processing bias in ASD have obtained mixed results, or have failed to find evidence of a local-processing advantage in ASD. Intact global processing has been documented using the Navon task, (Mottron et al., 2003; Ozonoff, Strayer, McMahon, & Filloux, 1994; Rinehart et al., 2000; Rondan & Deruelle, 2007), face processing tasks (Teunisse & de Gelder, 2003), and tasks assessing susceptibility to visual illusions (Hoy, Hatton, & Hare, 2004; Ropar & Mitchell, 1999; 2001; Rouse, Donnelly, Hadwin, & Brown, 2004). In one study, Rondan and Deruelle (2007) presented adults with ASD (Mean CA = 26.2 years) and CA-and-gender-matched TD adults (Mean CA = 27.8 years) with hierarchical stimuli based on a computerized Navon task (e.g., a circle comprised of a series of squares). Two comparison figures (e.g., a circle comprised of circles and a square comprised of squares) were also presented. Participants were required to identify the comparison figure that looked most like the target stimulus. Results indicated that participants with ASD did

not differ from TD individuals, and processed the global aspects of the stimuli in priority to the local elements.

Conflicting results have also been obtained regarding whether the local processing bias observed in individuals with ASD entails impaired or intact global processing. Several studies have failed to find evidence of a global orienting impairment despite a locally-biased processing style (Mottron et al., 2003; Plaisted et al., 1999; Rinehart, Bradshaw, Moss, Brereton, & Tonge, 2001; Rondan & Deruelle, 2007). For example, Mottron et al. (2003) administered a series of visual tasks assessing local and global processing to adolescents with HFA (Mean CA = 15.75 years) and CA- and IQ-matched TD adolescents (Mean CA = 15.17 years). Results indicated that while individuals with HFA demonstrated a superior ability to detect embedded figures relative to TD individuals, there were no group differences in participants' ability to process stimuli globally.

### *2.3.1 Factors that may Impact on Local-Global Information Processing in ASD*

Several researchers have identified factors that may account for conflicting findings regarding the nature of local-global processing in ASD. First, the information processing style exhibited by individuals with ASD may be contingent on the nature of the task, with different tasks eliciting different forms of processing. In support, Plaisted et al. (1999) reported that while children with ASD demonstrated a local processing advantage on a divided attention task, the same participants showed a global advantage using hierarchical stimuli on a selective attention task. Similarly, Mottron et al. (2003) reported that individuals with ASD demonstrated a local-processing advantage on an embedded figures task, however, showed a global processing advantage on a hierarchical letter task, and three configural grouping tasks.

Specific methodological variations that may impact on findings include whether the sample was comprised exclusively of participants with AD or included participants with AsD and PDD-NOS (Ozonoff et al., 1994; Plaisted et al., 1999); whether the participants knew that the target stimulus was going to appear at the local or global level as opposed to a random presentation of

stimuli (Mottron & Belleville, 1993; Plaisted et al., 1999), and the relative salience of the global and local elements of the stimuli.

Specific task instructions or questions may also play a critical role in task performance. Lamb and Robertson (1989) proposed that the results from the Navon task are highly influenced by minor variations in procedure and presentation, thus yielding inconsistent and unreliable findings. Similarly, Happé and Frith (2006), suggested that subtle modifications to test instructions on visual illusion tasks significantly enhances task performance for individuals with ASD (e.g., participants with ASD respond significantly more accurately when asked if lines ‘are’ verses ‘look’ the same). Likewise, explaining the nature of homographs to children with ASD enhances their ability to use the context from the preceding sentence to establish their meaning (Jolliffe & Baron-Cohen, 1999; Lopez & Leekam, 2003). Finally, Happé and Frith (2006) proposed that while individuals with ASD demonstrate a local processing bias when open-ended questions or task instructions are utilized, they show a capacity for global processing when explicitly instructed to do so (Plaisted et al., 1999). In support, Plaisted et al. (1999) demonstrated that children with AsD (Mean CA = 10.4 years) showed a bias for local information processing on a Navon task when required to divide attention between the local and global features of the stimuli. However, when instructed to attend to the stimulus on a more global level, they performed as well as CA- and- NVIQ-matched TD children. Similarly, Lopez, Donnelly, Hadwin, and Leekam (2004) reported that participants with ASD demonstrated a tendency for featural processing on a face-processing task, however, they showed configural processing when specifically cued to do so.

Other researchers have reported that children with ASD may demonstrate difficulties processing information globally after attending to the local elements of the stimuli (Mann & Walker, 2003; Plaisted et al., 1999). Plaisted et al. (1999) hypothesized that the innate tendency of individuals with ASD to attend to stimuli on a local level, coupled with an impaired ability to shift attention, leads to difficulties shifting attention from a local to global level of processing. Mann and Walker (2003) supported this notion, reporting that 10-year-old children with ASD

demonstrated difficulties transitioning from tasks requiring local processing to those requiring global processing. They concluded that, as a result of difficulties expanding attention from a narrow to broad focus, individuals with ASD may shift their attention to the global aspects of the stimulus more slowly and less frequently than TD children, resulting in a longer and more sustained focus on the local elements of the stimuli.

Age may also impact on the global processing abilities of children with ASD (Deruelle et al., 2004; Rondan & Deruelle, 2004). Deruelle et al. (2004) reported that older children with ASD made fewer errors processing faces globally (i.e., in the low spatial frequency condition) than younger participants, indicating that global information processing may improve with age and practice. These findings were confirmed in a subsequent study using the same stimuli with adults with ASD (Rondan & Deruelle, 2004). When considered with research demonstrating that TD children may process global stimuli less proficiently than adults (Pellicano & Rhodes, 2003), these findings may indicate that the development of global information processing in individuals with ASD may follow a similar trajectory to TD children; albeit at a later age.

Finally, there is some evidence to suggest the ability to process stimuli globally is mediated by cognitive ability (Hoy et al., 2004). However, as the majority of research examining central coherence in ASD has been conducted with children with HFA (van Lang, Bouma, Sytema, Kraijer, & Minderaa, 2006), this issue requires further research.

### *2.3.2 Summary of Research Examining WCC in ASD*

According to the WCC theory, individuals with ASD exhibit a cognitive style characterized by a local information processing bias. This pattern of perceptual-cognitive information processing has been supported by numerous studies demonstrating that individuals with ASD exhibit superior performance on tasks requiring segmentation skills, are less susceptible to visual illusions, and are impaired in their ability to process faces configurally relative to other groups of individuals. However, the findings are mixed, with several researchers failing to find evidence of a local processing bias. Conflicting results have also been obtained regarding whether

global processing is impaired or intact in individuals with ASD. Discrepancies in the research literature may be attributed to specific variations in the tasks and task instructions utilized, the characteristics of participants, and general methodological procedures. Thus, while there is some evidence to suggest that individuals with ASD exhibit a local information processing bias, the exact nature of information processing in ASD is unclear and requires further investigation.

### *2.3.3 Limitations of the WCC Hypothesis of ASD*

The WCC theory provides a possible explanation for aspects of ASD symptomatology related to narrow interests, a lack of generalization, attention to irrelevant details, and face processing difficulties (Happé & Frith, 2006; Mottron et al., 2006). However, the theory is controversial, with contradictory findings reported by studies employing different types of tasks and task procedures (van Lang et al., 2006). The considerable heterogeneity in the diagnosis of participants, sample size employed, and assessments and procedures utilized across studies makes it difficult to draw conclusions regarding the exact nature of local-global processing preferences in ASD.

There is also a lack of consensus in the literature regarding how WCC should be conceptualized. WCC was operationalized as an impaired ability to perceive stimuli globally in some studies, and as a preference for local or featural processing in others (van Lang et al., 2006). Additionally, Rondan and Deruelle (2007) proposed that researchers have failed to differentiate between tasks assessing global (i.e., the highest level of processing hierarchical stimuli) or configural (i.e., the interspatial relationships between the features of the stimuli) information processing; with recent studies demonstrating that individuals with ASD may be significantly more impaired in processing configural aspects of stimuli (Behrmann, Avidan et al., 2006; Brosnan et al., 2004; Deruelle, Rondan, Gepner, & Fagot, 2006; Rondan & Deruelle, 2007).

The extent to which WCC can account for ASD symptomatology is also limited by the finding that only a subset of individuals with ASD demonstrate a local processing bias (Happé & Frith, 2006). Furthermore, WCC is observed in individuals with other disorders, such as learning

disabilities (Jarrold & Russell, 1997), schizophrenia (Chen, Nakayama, Levy, Matthyse, & Holzman, 2003), Williams Syndrome (Bellugi, Lichtenberger, Jones, Lai, & George, 2000), depression (Gasper & Clore, 2002) and right hemisphere damage (Robertson & Lamb, 1991).

There is also a lack of understanding regarding the neurological processes that underlie central coherence. While the atypicalities in the dorsal stream/magnocellular pathway (Pellicano et al., 2005) and right hemisphere (Heinze, Hinrichs, Scholz, Burchert, & Mangun, 1998), and reduced connectivity throughout the brain (Just, Cherkassky, Keller, & Minshew, 2004) have been implicated, further research is needed to fully understand these processes (Hill & Frith, 2003).

Finally, as the majority of research studies have examined WCC in individuals with HFASD, the extent to which these findings can be generalized to lower functioning individuals is questionable and warrants further consideration.

#### *2.3.4 Enhanced Perceptual Functioning Theory of ASD*

An alternative explanation for the WCC deficits observed in individuals with ASD is the Enhanced Perceptual Functioning theory (EPF; Mottron & Burack, 2001). According to the EPF theory, individuals with ASD display enhanced low-level perception and attention to detail. Low level perception refers to the early processing of information from sensory modalities (Mottron & Burack, 2001; Mottron et al., 2003; Mottron, Peretz, & Ménard, 2000; O'Connor & Kirk, 2008; Plaisted, 2001). The heightened perceptual processing exhibited by individuals leads to difficulties filtering and controlling sensory input. The relationships between high- and low-level processing are then altered, and other facets of development are derailed (Mottron & Burack, 2001). A common premise of both the WCC and EPF theories is that individuals with ASD show a local information processing bias. However, the EPF theory proposes that an increase in the perception of local details decreases the extent to which information is processed globally (i.e., in context), however, global processing remains intact.

Many of the research findings supporting the EPF theory of ASD also support the WCC account. These include difficulties inhibiting the processing of irrelevant details (Rinehart et al.,

2000), including extraneous background stimuli such as smells, noises and lights (Sainsbury, 2000), and heightened sensitivity and atypical sensory responses (e.g., pain) to common environmental stimuli (Rogers, Hepburn, & Wehner, 2003; Sainsbury, 2000; Watling, Deitz, & White, 2001). Individuals with ASD also demonstrate enhanced local processing of pitch (Bonnell et al., 2003) and other musical stimuli (Heaton, 2003), superior visual search (O’Riordan et al., 2001; Plaisted et al., 1998a) and enhanced discrimination of highly similar stimuli (Plaisted, O’Riordan, & Baron-Cohen, 1998b). In contrast, other findings cited in support of the EFP theory would not be predicted by the WCC account, for example, enhanced learning of visual stimuli including shorter learning times and superior recall of map paths (Caron, Mottron, Rainville, & Chouinard, 2004).

#### 2.4 Executive Functions (EF)

Executive Functions (EF) are the cognitive functions that are necessary for the control and regulation of goal-directed behaviors (Hill, 2004; Verté, Geurts, Roeyers, Oosterlaan, & Sergeant, 2005). While there is some disagreement regarding the exact components of executive functions (Liss et al., 2001; Russo et al., 2007), they involve behaviours such as identifying changes in the current circumstances, inhibiting (or stopping) previously reinforced but contextually inappropriate responses, rapidly retrieving relevant information, generating flexible and alternative courses of action, forming abstract concepts, focusing and sustaining attention and mental effort, and self monitoring and correcting behaviour (Barkley, 1997; Liss et al., 2001).

While the findings regarding the nature and extent of EF impairment in ASD are mixed, evidence of EF deficits in individuals with ASD across a wide range of chronological and mental ages have been documented (Geurts et al., 2004; Ozonoff & Strayer, 1997; 2001; Ozonoff et al., 2004; Verté et al., 2006; see Hill, 2004 for a recent review). In particular, deficits in cognitive set-shifting (Corbett, Constantine, Hendren, Rocke, & Ozonoff, 2009; Geurts et al., 2004; Ozonoff et al., 2004; Ozonoff, South, & Provencal, 2005; Verté et al., 2006), inhibition (Bishop & Norbury,



2005a; Geurts et al., 2004; Johnson et al., 2007), working memory (WM; Landa & Goldberg, 2005; Steele, Minshew, Luna, & Sweeney, 2007; Williams, Goldstein, Carpenter, & Minshew, 2005), and planning (Geurts et al., 2004; Verté et al., 2006) have been documented. As a result, some researchers have suggested that executive dysfunction may underlie some of the core features of ASD symptomatology (Hill & Bird, 2006; Pennington & Ozonoff, 1996). Other researchers have established a relationship between neuroanatomical atypicalities in the frontal cortex and executive dysfunction in individuals with ASD, providing further support for the EF theory of ASD (Sanders, Johnson, Garavan, Gill, & Gallagher, 2008; Schroeter, Zysset, Wahl, & von Cramon, 2004). Anatomic (Carper & Courchesne, 2000; 2005; Schmitz et al., 2006; Voelbel, Bates, Buckman, Pandina, & Hendren, 2006), metabolic (Murphy et al., 2002) and functional (Pierce, Haist, Sedaghat, & Courchesne, 2004; Schmitz et al., 2006) atypicalities have been reported.

#### *2.4.1 Set-Shifting*

Set-shifting involves disengaging attention from an idea, response, or cognitive strategy, and generating and implementing new ideas and behaviors (Stahl & Pry, 2005). The development of set-shifting in TD children follows a predictable developmental sequence, with significant developments in representational flexibility occurring between 3 and 6 years of age (Frye, Zelazo, & Palfai, 1995; Zelazo, Muller, Frye, & Marcovitch, 2003).

Impairments in set-shifting ability are among the most well documented EF deficits in children with ASD. A number of aspects of ASD symptomatology have been linked to impaired set-shifting, including rigid and repetitive behavior, resistance to change, perseverative, narrow interests, and difficulties generating different thoughts or actions in response to situational and task changes (Lopez, Lincoln, Ozonoff, & Lai, 2005; South, Ozonoff, & McMahon, 2007; Yerys et al., 2009). A failure to engage in pretence (Baron-Cohen, 1987; Jarrold, Boucher, & Smith, 1996), impaired development of JA (Stahl & Pry, 2002), communicative atypicalities (Bishop & Norbury, 2005b), and difficulties adapting to change (Shouten, Oostrom, Peters, Berloop, & Jennekens-Schinkel, 2000) have also been linked to impaired set-shifting.

Many assessments of set-shifting examine the extent to which individuals are able to abandon previously correct rules or strategies (e.g., sorting cards according to their colour) when given feedback that the rule or strategy is no longer correct, and apply a new rule or strategy (e.g., sorting the cards according to their shape; Hill, 2004). The Wisconsin Card Sorting Test (WCST; Heaton, Chelune, Talley, Kay, & Curtis, 1993), The Dimensional Change Card Sort (DCCS; Frye et al., 1995) and the Intradimensional-Extradimensional shift – tests (ID/ED; Hughes, Russell, & Robbins, 1994) are commonly used set-shifting assessments (Ozonoff & McEvoy, 1994; Shu, Lung, Tien, & Chen, 2001; Verté et al., 2006; Zelazo, Frye, & Rapus, 1996).

A number of researchers examining set-shifting in ASD have reported that these individuals perseverate on maladaptive, previously reinforced strategies, demonstrate deficiencies in their use of feedback to flexibly shift problem solving strategies, and do not appear to learn from their mistakes (Corbett et al., 2009; Geurts et al., 2004; Goldstein, Johnson, & Minshew, 2001; Liss et al., 2001; Ozonoff, 1995; Ozonoff et al., 2004; 2005; Shu et al., 2001; Verté et al., 2006). Using the WCST, Goldstein et al. (2001) compared 103 high-functioning individuals with ASD and 103 TD individuals matched on CA (Mean CA = 18.0 years), gender, educational level, and IQ. Results indicated that individuals with ASD achieved a lower number of categories and made a significantly higher percentage of perseverative errors than TD individuals. Similarly Verté et al. (2006) used the WCST to examine set-shifting ability in 50 children with HFA (Mean CA = 8.7 years), 37 children with AsD (Mean CA = 8.5 years), 25 children with PDD-NOS (Mean CA = 8.5 years) and 47 TD children (Mean CA = 9.4 years). Groups were matched on gender, CA and PIQ. Results indicated that children with HFA, AsD and PDD-NOS made significantly more perseverative responses than TD children. However, significant group differences remained for only the HFA and PDD-NOS groups when CA and IQ were co-varied. Similarly, Geurts et al. (2004) used the WCST to examine set-shifting in 54 children with ADHD (Mean CA = 9.3 years), 41 children with HFA (Mean CA = 9.4 years), and 41 TD children (Mean age = 9.1 years). Groups were matched on CA. Results indicated that children with HFA demonstrated a higher percentage

of perseverative responses than both TD and ADHD children. Group differences remained after CA and IQ were co-varied. Finally, using the ID/ED task, Ozonoff et al. (2004) examined attentional set-shifting in 79 individuals with ASD (Mean CA = 15.7 years) and 70 TD individuals (Mean CA = 16.0 years) matched on CA, gender, and IQ. Results indicated that participants with ASD were impaired on the ED shift component of the ID / ED task relative to TD participants; in which they were required to inhibit a pre-potent response and shift attention away from the previously correct stimulus dimension. Deficits were observed for individuals with both higher and lower cognitive abilities.

Other researchers have reported that children with ASD are impaired on some aspects of conceptual set-shifting but not others (Pascualvaca, Fantie, Papegeorgiou, & Mirsky, 1998). Pascualvaca et al. (1998) examined the attentional capabilities of 23 children with ASD (Mean CA = 8.7 years), 23 TD children matched on VMA (Mean CA = 5.11 years), and an additional 23 TD children matched on performance mental age (PMA; Mean CA = 6.7 years). To assess shifting attention, the traditional WCST and two computerized tasks assessing different aspects of shifting attention were administered. Participants with ASD completed fewer categories and made significantly more non-perseverative and perseverative errors on the WCST relative to both groups of TD children; however they did not differ from either of the control groups on the computerized set-shifting assessments.

Other studies have failed to find any differences between individuals with ASD and other groups of individuals on set-shifting tasks (Bogte, Flamma, van der Meere, & van Engeland, 2008; Dawson et al., 2002; Happé, Booth, Charlton, & Hughes, 2006; Schmitz et al., 2006; Yerys, Hepburn, Pennington, & Rogers, 2007). Happé et al. (2006) used the ID / ED task to examine set-shifting in 32 individuals with ASD (Mean CA = 10.9 years), 30 individuals with ADHD (Mean CA = 11.6 years) and 32 TD individuals (Mean CA = 11.2 years) matched on CA, and IQ. No significant group differences were found on either the ID or ED components of the task. Similarly, Liss et al. (2001) compared 34 children with developmental language disorders (DLI; Mean CA =

9.1 years) and 21 children with HFA (Mean CA = 9.2 years) using the WCST. Groups were matched on IQ and CA. Results indicated that there were no group differences on the total number of categories achieved or number of errors made, however children with HFA made significantly more perseverative errors than children with DLD. These group differences disappeared, however, when VIQ was controlled for. Finally Bogte et al. (2008) used a computerized version of the Sternberg response bias paradigm (Steinberg, 1966) to examine set-shifting in 23 adults with HFA (Mean CA = 28 years) and 32 CA-and-IQ-matched TD adults (Mean CA = 28 years). Results indicated that individuals with ASD did not differ from TD individuals in their set-shifting ability.

Taken together, intact performance on the computerized 'same-different' task (Pascuavala et al., 1998), the total number of categories achieved on the WCST (Liss et al., 2001), and the ID component of the ID/ED task (Happé et al., 2006), indicates that individuals with ASD are able to shift their attention continuously between stimuli and different dimensions of stimuli when given sufficient time to do so. Conversely, difficulties with the ED component of the ID / ED task (Ozonoff et al., 2004) and the higher percentage of perseverative errors often reported in individuals with ASD on the WCST (Geurts et al., 2004; Goldstein et al., 2001; Liss et al., 2001; Verté et al., 2006), suggests that they are impaired in shifting attention when attention has been previously engaged for a period of time (Pascuavala et al., 1998). An impaired ability to shift cognitive sets may thus evolve from difficulties disengaging and re-establishing the focus of attention. These deficits have been observed across different age ranges and IQ levels (Landa & Goldberg, 2005; Liss et al., 2001; Ozonoff et al., 2004), and are reportedly maintained over time (Ozonoff & McEvoy, 1994).

Other researchers have proposed that computerized assessments of shifting attention may enhance the performance of individuals with ASD by decreasing the social element of the procedure (Ozonoff, 1995; Pascualvaca et al., 1998). In support of this notion, no group differences were observed on the computerized shifting task utilized by Pascuavala et al. (1998), the ID / ED task employed by Happé et al. (2006), or on other computerized assessments of set-

shifting ability (Bogte et al., 2008). On a traditional WCST, knowing when to switch matching variables relies almost exclusively on an individual's ability to respond to verbal and social feedback from the examiner. Therefore, if TD individuals are more proficient at interpreting verbal feedback and inadvertent non-verbal cues than individuals with ASD, group differences are more likely to be observed. Lower scores on the traditional version of the WCST relative to control subjects may thus, in part, be attributed to a diminished ability to interpret social information in individuals with ASD. In contrast, tangible visual and auditory effects presented in computer analogue tasks may increase motivation and provide feedback in a format that enhances their performance. These findings are consistent with Ozonoff (1995), who reported that individuals with ASD performed significantly better on a computerized version of the WCST than the standard version, and Garretson, Fein, and Waterhouse (1990) who reported that tangible, but not social reinforcement, improves attention performance in individuals with PDD.

#### *2.4.2 Inhibition*

Inhibition refers to the process of stopping a behaviour in the presence of the stimulus for the behavior (Barkley, 1997). Three different forms of behavioural inhibition have been identified: stopping pre-potent or previously reinforced responses, discontinuing ongoing responses, and inhibiting or delaying responses to sources of interference (i.e., distractions) while engaged in another task (Barkley, 1997). For TD children, significant developments in inhibitory control are observed in the preschool years, and they continue to become increasingly efficient into adulthood (Jones, Rothbart, & Posner, 2003).

Decreased or slower inhibitory control has been linked to a myriad of impairments in individuals with ASD, including deficits in attention, social interaction, and communication skills (Blair, 2002; Carlson & Moses, 2001). Inappropriate emotional responses, increased repetitive, stereotyped behaviours (Schmitz et al., 2006), and deficits in social cognition, including theory of mind, emotional understanding, and moral conscience have also been related to impaired inhibition (Carlson, Moses, & Breton, 2002; Hughes, 1998).

A number of researchers have reported that individuals with ASD are impaired in their ability to inhibit a pre-potent response (Biro & Russell, 2001; Bishop & Norbury, 2005a; Geurts et al., 2004; Johnson et al., 2007; Russell, Hala, & Hill, 2003; Verté et al., 2006). Inhibition deficits have been observed using various experimental protocols, including the automated windows task (Russell et al., 2003), Go–No-Go task (Ozonoff et al., 1994), an oculomotor antisaccade task (Luna, Doll, Hegedus, Minshew, & Sweeney, 2007) an oculomotor delayed-response task (Minshew, Luna, & Sweeney, 1999), and the detour reaching task (Biro & Russell, 2001).

Geurts et al. (2004) used the Change Task (De Jong, Coles, & Logan, 1995), the Circle Drawing Task (Bachorowski & Newman, 1990), and the Opposite Worlds of the Test of Everyday Attention for Children (TEA-Ch; Manly et al., 2001) tasks to examine inhibition in 41 TD children (Mean CA = 9.1 years), 54 children with ADHD (Mean CA = 9.3 years) and 41 children with HFA (Mean CA = 9.4 years). Groups were matched on CA, and participants with ASD and ADHD were additionally matched on FSIQ. Results indicated that participants with HFA were significantly slower at inhibiting a pre-potent response than TD, but not ADHD participants, and were significantly more impaired at inhibiting an ongoing response relative to both TD and ADHD participants. More recently, Johnson et al. (2007) examined sustained attention and response inhibition in 23 children with ADHD (Mean CA = 10.5 years), 21 children with HFA (Mean CA = 12.2 years) and 18 TD children (Mean CA = 11.1 years) using the Sustained Attention to Response Task (SART; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997). Groups were matched on CA and IQ. In the SART, children were required to press a button whenever a digit appeared on the computer screen (the ‘go’ trials), and inhibit responding to a pre-determined digit (the ‘no-go’ trials). Digits were presented in either a fixed (fixed trials) or random (random trials) order. Children with ASD did not differ from TD children in sustaining attention or inhibiting their responses to the ‘no-go’ digit on the fixed trials of the SART. In contrast, participants with ADHD were significantly impaired on these measures relative to children with ASD and TD children. However, both participants with ADHD and ASD were significantly impaired in inhibiting their

response to the 'no-go' digit in the random trials of the SART relative to TD participants. Johnson et al. (2007) concluded that individuals with ASD are impaired in their ability to inhibit a response in the random, but not fixed SART trials because compensatory cognitive mechanisms (e.g., an understanding of the predictable pattern of digit presentation in the fixed trials) cannot be used to enhance task performance when the stimuli are presented randomly.

Other studies using different research methodologies have found intact inhibitory skills in individuals with ASD (Barnard, Muldoon, Hasan, O'Brien, & Stewart, 2008; Eskes, Bryson, & McCormick, 1990; Griffith, Pennington, Wehner, & Rogers, 1999; Ozonoff & Jensen, 1999; Ozonoff & Strayer, 1997). Experimental tasks that have failed to find inhibition deficits in these individuals include the Stroop (Goldberg, Mostowsky et al., 2005; Ozonoff & Jensen, 1999) and negative priming tasks (Ozonoff & Strayer, 1997). For example, Ozonoff and Strayer (1997) used two computerised inhibition tasks: the Stop-Signal paradigm (Logan, 1994; Logan, Cowan, & Davis, 1984) and a negative priming task (Tipper, 1985), to examine inhibition in individuals with HFA (Mean CA = 13.9 years) and CA- and IQ-matched TD individuals (Mean CA = 13.1 years). Results indicated that participants with ASD did not differ from TD participants in inhibiting their responses to neutral, pre-potent, or extraneous visual stimuli. More recently, Goldberg, Mostowsky et al. (2005) found no group differences in the Stroop Task (Golden, 1978) for 17 children with HFA (Mean CA = 10.3 years), 12 children with ADHD (Mean CA = 9.8 years) and 32 TD children (Mean CA = 10.4 years).

Taken together, these findings suggest that individuals with ASD may be unimpaired in their ability to withhold a response following a cue to do so (Ozonoff et al., 1994; Ozonoff & Strayer, 1997), however, they are significantly less able than TD children to demonstrate an alternative, incompatible response to a primed or pre-potent response (e.g., pointing away from a desired object in order to obtain it; Biro & Russell, 2001; Russell et al., 2003).

### 2.4.3 Working Memory (WM)

Working memory (WM) is defined as the active process by which mental representations (i.e., the things to be ‘remembered’) are simultaneously stored and processed ‘online’. It involves processing representations despite distractions and interference, and the subsequent use of the representations in goal-directed behaviour (Baddeley, 1986; Ozonoff & Strayer, 2001; Roberts & Pennington, 1996).

The WM system is comprised of a number of specialized components. While there is a lack of consensus regarding the exact nature and composition of these components (Alloway, Gathercole, & Pickering, 2006; Bayliss, Jarrold, Gunn, & Baddeley, 2003), it has been proposed that separate memory systems are responsible for the temporary storage of visuo-spatial (e.g., physical features, dimensions and locations), and phonological (i.e., auditory [sound and verbal] information) representations. A third system, known as the ‘episodic buffer’ links visual, verbal and auditory information within the correct chronological sequence (Baddeley, 2000). One or more additional systems then coordinate and oversee the temporary memory systems, control switching between tasks and the retrieval of information, oversee the shifting and focus of attention, and activate selected representations in long-term memory (Van Leijenhorst, Crone, & Van der Molen, 2007). For TD children, considerable gains in WM are observed between 4 and 8 years of age, at which time adult levels of performance are reached on some measures (Lucianna & Nelson, 1998).

Studies examining WM functioning in children and adults with ASD have yielded inconsistent results. Earlier studies utilizing classic planning tasks to assess WM have consistently reported that children with ASD are impaired in their ability to hold strategies ‘online’ while simultaneously evaluating, and then selecting the best strategy (Bennetto, Pennington, & Rogers, 1996; Ozonoff & Jensen, 1999; Ozonoff & McEvoy, 1994; Ozonoff, Pennington, & Rogers, 1991). However, studies employing different methodologies have been less consistent. While a number of studies have found WM deficits in individuals with ASD (Barnard et al., 2008; Corbett et al., 2009;



Goldberg, Mostofsky et al., 2005; Landa & Goldberg, 2005; Steele et al., 2007; Verté et al., 2006), others have failed to identify any significant differences between individuals with ASD and other groups of individuals (Edgin & Pennington, 2005; Geurts et al., 2004; Ozonoff & Strayer, 2001; Yerys et al., 2007).

Other studies, however, have found that the degree of WM and retrieval impairment observed in individuals with ASD depends on the complexity of the information to be recalled. Research indicates that when the complexity of the information increases, individuals with ASD perform more poorly than comparison groups (Fein et al., 1996). This is reportedly due to their failure to use context and organizational strategies (e.g., making semantic connections between new and previously learned information) to facilitate remembering (Fein et al., 1996; Renner, Klinger, & Klinger, 2000; Steele et al., 2007). In support, individuals with ASD are reportedly impaired in their ability to remember complex visual information such as faces and visual sequences (Klin et al., 1999; Williams, Goldstein, & Minshew, 2006a), and auditory information such as stories (Fein et al., 1996; Williams et al., 2006a). Children with ASD also remember significantly less about recent experiences than their DD and TD peers (Bennetto et al., 1996; Boucher, 1981; Millward, Powell, Messer, & Jordan, 2000).

In summary, research examining WM in individuals with ASD supports the notion of an impaired ability to remember information when required to manipulate the information 'online' in these individuals. However, the degree of WM impairment may be influenced by the specific task methodology employed, such as the complexity of the information to be recalled and other, concurrent task demands (Russo et al., 2007).

#### *2.4.4. Planning*

Planning refers to the process of identifying and sequencing a series of actions or steps to achieve a specific goal. Planning involves establishing a goal or objective, selecting the steps or actions needed to complete the goal from available alternatives, implementing the plan, continuously monitoring progress towards the goal, and evaluating and modifying the actions or

steps as needed (Hill, 2004). Children with planning deficits may appear disorganized, have difficulties completing tasks on time, and may find it difficult to know how to start tasks or projects with multiple steps.

A number of studies have examined planning in children and adolescents with ASD. Impairments have been reported in many studies relative to age-and-IQ-matched TD, and ID individuals, and in individuals with other developmental disorders such as ADHD, Tourette Syndrome and dyslexia (Bennetto et al., 1996; Bramham et al., 2009; Geurts et al., 2004; Hughes et al., 1994; Ozonoff & Jensen, 1999; Ozonoff & McEvoy, 1994; Ozonoff et al., 1991; Robinson, Goddard, Dritschel, Wisley, & Howlin, 2009; Verté et al., 2006). Planning impairments in ASD appear to be maintained over time (Ozonoff & McEvoy, 1994). Geurts et al. (2004) used the Tower of London task (ToL; Krikorian, Bartok, & Gay, 1994) to examine planning skills in 54 children with ADHD (Mean CA = 9.3 years), 41 children with HFA (Mean CA = 9.4 years), and 41 TD children (Mean age = 9.1 years). Groups were matched on CA. Participants with ASD required significantly more time to complete the problem within the required number of steps, and were significantly less able to plan ahead, sequence their actions, and flexibly generate alternative approaches to the task, relative to participants with ADHD and TD participants. More recently, Bramham et al. (2009) examined planning and strategy formation skills in 45 adults with ASD (Mean CA = 32.76 years), 53 adults with ADHD (Mean CA = 31.04 years) and 31 TD adults (Mean CA = 32.81). Groups were matched on CA and gender. Planning and strategy formation were assessed using the zoo map and key search tasks from the Behavioural Assessment of Dysexecutive Syndrome test respectively (BADS: Wilson, Alderman, Burgess, Emslie, & Evans, 1996). Results indicated that participants with ASD were significantly slower to develop, implement and execute a plan, relative to TD participants and those with ADHD.

However, other studies have failed to find differences in the planning skills of individuals with ASD, relative to TD and DD individuals (Liss et al., 2001; Ozonoff, South, & Miller, 2000). Using the Mazes subtest from the WISC-R (Lezak, 1995), Liss et al. (2001) reported that children

with ASD (Mean CA = 9.0 years) were unimpaired in their ability to use strategy to complete increasingly complex mazes relative to DD children (Mean CA = 10.6 years). Similarly, using a computerised version of Stockings of Cambridge task (CANTAB), Happé et al. (2006) reported that planning skills were unimpaired in children with HFASD (Mean CA = 10.9 years) relative to CA and IQ-matched TD children (Mean CA = 11.2 years) and children with ADHD (Mean CA = 11.6 years).

Taken together, these findings support the notion of a planning impairment in some individuals with ASD. The inconsistent findings may be related to significant heterogeneity in the characteristics of the participants and methodologies employed across studies. According to Hill (2004), impaired planning skills in individuals with ASD may also be more evident on tasks requiring longer and more complex sequences of actions.

#### *2.4.5. EF and Language Abilities*

Several researchers have suggested that EF abilities in individuals with ASD may be mediated by language abilities. Russell et al. (1999) proposed that the EF deficits may stem from an impaired ability to use self-directed speech to guide and regulate behaviour. According to this hypothesis, an impaired ability to self-remind and rehearse task-relevant rules may impede the individuals' performance on EF tasks requiring a response that conflicts with a salient, pre-potent response. Children with weak language abilities may therefore perform poorly on EF tasks due to difficulties verbalizing the rules of the task (Bishop & Norbury, 2005a). The importance of language in response inhibition was further supported by Wisdom, Dyck, Piek, Hay, and Hallmayer (2007), who reported that children with mixed receptive expressive language disorder (RELD), performed more poorly than children with ASD on a measure of response inhibition. Similarly, Bishop and Norbury (2005a) examined response inhibition using verbal and non-verbal subtests from the TEA-Ch (Manly et al., 2001) using 14 children with HFA, 25 children with pragmatic language impairment, 17 children with a specific language impairment, and 18 TD children. All

children were 6 to 10 years of age. The results indicated that inhibition impairments were not specific to ASD, and were related instead to co-morbid attention and structural language deficits.

Other evidence for a relationship between language ability and EF skills in individuals with ASD was documented by Liss et al. (2001), who failed to find group differences in the set-shifting ability of participants with ASD and DLD when VIQ was controlled for. Furthermore, strong correlations were established between VIQ and set-shifting, planning, inhibition and sustained attention for participants with ASD. On the basis of these findings, Liss et al. (2001) concluded that EF impairments in individuals with ASD were strongly mediated by language deficits.

However Joseph, McGrath, and Tager-Flusberg (2005) raised several criticisms of Liss et al.'s (2001) interpretation of the relationship between EF and language skills; citing problems with the statistical analyses employed (Liss et al., 2001; Miller & Chapman, 2001), and the failure to account for factors that may impact on the development of EF and language skills (e.g., general cognitive ability). To further examine these issues, Joseph et al. (2005) examined the link between EF and language skills in 37 children with AD (Mean CA = 7.11) and 31 TD children (Mean CA = 8.3) matched on CA, VIQ, and PIQ. A series of EF tasks were administered to assess planning (NEPSY Tower; Korkman, Kirk, & Kemp, 1998), WM (Day–Night, NEPSY Knock-Tap; Korkman et al., 1998; Forward and Backward Word and Block Span: Isaacs & Vargha-Khadem, 1989), and inhibition (Day–Night, NEPSY Knock-Tap; Korkman et al., 1998). Language abilities were assessed using Peabody Picture Vocabulary Test (PPVT–III; Dunn & Dunn, 1997) and the Expressive Vocabulary Test (EVT; Williams, 1997). There was no relationship between language abilities and EF skills for children with ASD. However, for TD children, performance on EF tasks was positively correlated with language ability. Landa and Goldberg (2005) supported these findings, proposing that there was no relationship between spatial WM, planning and set-shifting (Cambridge Neuropsychological Test Automated Battery (CANTAB); Cambridge Cognition, 1996), and figurative language comprehension (Test of Language Competence; TLC; Wiig & Secord, 1989), complex sentence formation (CELF-R; Semel, Wiig, & Secord, 1987) or VIQ for 19

children with HFA (Mean CA = 11.01 years) and 19 CA, gender and IQ-matched TD children (Mean CA = 11.00 years).

Taken together, these findings indicate that there may be a relationship between EF and language in children with ASD. However, the exact nature of the relationship remains unclear, and may be strongly influenced by the specific aspects of EF or language assessed; or by specific participant characteristics such as CA and / or cognitive ability. It is also unclear whether language skills relate to the use of self-regulatory speech to enhance performance on EF tasks, or reflect difficulties with other aspects of attention and / or metacognition in individuals with ASD.

#### *2.4.6 EF and Cognitive Abilities*

Several researchers have proposed that EF skills may be related to general cognitive abilities in individuals with ASD. Liss et al. (2001) established a positive relationship between IQ and EF in children with HFA. EF deficits have also been documented in low- but not high-functioning individuals with ASD (Happé et al., 2006; Ozonoff et al., 2004). Consistent with this, a number of researchers have documented more severe planning deficits in individuals with ASD and lower cognitive skills (Geurts et al., 2004; Hughes et al., 1994; Ozonoff & Jensen, 1999; Ozonoff & McEvoy, 1994; Ozonoff et al., 1991), relative to those with HFASD (Happé et al., 2006). Several researchers have also suggested that WM deficits are more likely to be observed in younger and more cognitively impaired individuals (Griffith et al., 1999; Russell et al., 1996; Russo et al., 2007).

Other researchers have reported that EF deficits may be related to general information processing limitations, with individuals with ASD processing information less efficiently and more slowly than other groups of individuals (Bogte et al., 2008; Minshew, 2002; Williams et al., 2006). Bogte et al. (2008) examined set-shifting, memory, and inhibition in 23 adults with ASD and 32 CA and IQ-matched neurotypical adults using a variant of the Sternberg reaction time paradigm (1966). In this task, participants were presented with a set of two ‘memory’ consonants followed by a set of two display consonants on a computer screen. Participants were required to press the ‘yes’

button if there was a match between one of the memory consonants and one of the display consonants, and the 'no' button if there was no match. Participants with ASD did not differ from TD participants in their ability to inhibit a response or shift response sets, however they demonstrated significantly slower reaction times. Bogte et al. (2008) concluded that adults with ASD were slower at processing information than TD adults, and that slowed information processing may contribute to the deficits observed on complex EF tasks. Slowed or inefficient information processing may thus significantly hamper the performance of individuals with ASD on EF tasks, as observed in elderly populations (Rabbitt et al., 2007; Salthouse, 2005), and may lead to an overestimation of the EF impairment observed in these individuals when completing complex cognitive tasks (Bogte et al., 2008).

#### *2.4.7 Summary of Research Examining EF in ASD*

Taken together, the research literature examining EF in children and adults with ASD suggests that specific aspects of set-shifting, inhibition, memory and planning skills are impaired in these individuals. EF impairments appear to be most evident on tasks requiring the demonstration of more complex, higher-order cognitive skills, or on tasks requiring multiple EF skills to be employed simultaneously (e.g., set-shifting tasks requiring cognitive flexibility, sustained attention, WM, and inhibition skills for successful completion). A relatively intact performance is observed on tasks with fewer information processing demands.

Several researchers have suggested that EF abilities in individuals with ASD may be mediated by other factors, such as language, cognitive, and information processing abilities. However, the exact nature of the relationship between these variables is unclear due to mixed findings, and significant differences in the areas of EF examined, assessments utilized, age, developmental level, severity of ASD symptomatology, control groups, and matching procedures employed (Russo et al., 2007; see Burack, Iarocci, Flanagan, & Bowler, 2004 for a review of methodological concerns).

#### *2.4.8 Limitations of EF Theory of ASD*

A major criticism of the EF theory of ASD pertains to the extent to which EF assessment tasks discriminate individuals with ASD from other clinical populations, or from those who are TD. It is well documented that EF deficits are observed in several other disorders (Rinehart et al., 2001; Sinzig, Morschi, Bruning, Schmidt, & Lehmkuhl, 2008). Individuals with frontal-lobe pathology, ADHD, Schizophrenia, OCD and Tourette Syndrome perform similarly to individuals with ASD on some tests of EF. Studies endeavouring to differentiate individuals with ASD from other disorders on the basis of EF skills have yielded inconsistent results. Several researchers have failed to differentiate different disorders on the basis of EF skills (Hill, 2004; Nydén, Gillberg, Hjelmquist, & Heiman, 1999). Other researchers have proposed that ASD is characterised by impaired planning, set-shifting (Corbett et al., 2009; Geurts et al., 2004; Ozonoff & Jensen, 1999; Ozonoff et al., 2004; Ozonoff & Strayer, 1997) and WM (Corbett et al., 2009; Goldberg, Mostowsky et al., 2005; Landa & Goldberg, 2005; Verté et al., 2006), relative to TD and ADHD comparison groups. In contrast, the EF deficits in ADHD are more restricted to inhibition and vigilance (Corbett & Constantine, 2006; Geurts et al., 2004; Goldberg, Mostowsky et al., 2005; Verté et al., 2006). Researchers have also reported that the EF deficits observed in individuals with ASD are more generalised and severe than in other disorders (Corbett et al., 2009; Geurts et al., 2004; Goldberg, Mostowsky et al., 2005; Verté et al., 2006). The discriminant validity of EF assessments is further complicated by the complexity and multifaceted nature of the EF construct. This not only makes it difficult to discriminate between different disorders, but makes it difficult to decipher which areas of EF are impaired or intact in individuals with ASD. This issue is exacerbated by the different cognitive and language abilities of participants, degree of ASD severity, and EF assessments used in these studies (Morgan & Lilienfeld, 2000).

Related to this, most EF assessments do not measure one domain of EF. Rather, several interrelated domains are assessed (Geurts et al., 2004; Romaine et al., 2004). Thus, an individual's performance on a given EF task may be mediated by other aspects of EF necessary for task

completion, or by non-executive components of the task (Collette & Van der Linden, 2002; Romaine et al., 2004). Successful performance on the WCST, for example, not only requires set-shifting ability, but problem-solving and decision making skills (Romaine et al., 2004), the ability to inhibit a response, disengage attention, and hold previous and future responses in one's WM (Rinehart et al., 2001).

Furthermore, the extent to which EF deficits relate to the core symptomatology of ASD is unclear due to inconsistent findings regarding the nature of this relationship. EF deficits have been related to impaired ToM (Russell et al., 1999), JA (Dawson et al., 2002; Nichols et al., 2005) and adaptive behaviour (Gilotty, Kenworthy, Sirian, Black, & Wagner, 2002; Happé et al., 2006), and the presence of rigid and repetitive behaviour (Yerys et al., 2009). However, other researchers have failed to find evidence of a relationship between EF deficits and ASD symptomatology, questioning the notion that executive dysfunction is a core deficit in ASD. Dawson et al. (1998) reported that there was no relationship between executive dysfunction and social behaviour. Similarly Liss et al. (2001) reported that relationships between EF scores and adaptive functioning and degree of ASD symptomatology were no longer significant when VIQ was controlled for. More recently, Stahl and Pry (2002) reported that set-shifting was related to JA in TD individuals but not those with ASD, and Joseph and Tager-Flusberg (2004) concluded that EF skills were related to communication symptoms but not to social interaction or repetitive behaviours in individuals with ASD. Finally, Landa and Goldberg (2005) found no relationship between executive and social dysfunction as assessed by the Autism Diagnostic Interview – Revised (ADI-R; Rutter, Le Couteur, & Lord, 2003) and Autism Diagnostic Observation Schedule – Generic (ADOS-G; DiLavore, Lord, & Rutter, 1995; Lord et al., 1989).

The extent to which EF deficits are universal or near universal in individuals with ASD is also unclear, questioning the extent to which these deficits can be considered a primary impairment of the disorder (Rajendran & Mitchell, 2007). Ozonoff et al. (1991) reported that 96% of individuals with ASD exhibited EF deficits. However, a more recent study by Pellicano, Maybery,



Durkin, and Maley (2006), reported that only 50% of participants with ASD were impaired on measures of EF. As the majority of studies examining EF in individuals with ASD have failed to document the exact prevalence of executive dysfunction within the group of participants with ASD (Liss et al., 2001), the incidence of EF deficits in individuals with ASD remains unclear.

Finally, the primacy of the EF impairment in ASD is questionable. Several researchers have suggested that EF skills are intact in early development (Dawson et al., 2002; Griffith et al., 1999; Liss et al., 2001; Russell et al., 1999; Yerys et al., 2007), and that impairments in EF skills may become more prominent with age (Yerys et al., 2007). According to Yerys et al. (2007) later-developing EF impairments may be acquired as a secondary deficit to the presence of other ASD symptomatology early in life (Yerys, et al., 2007), such as deficient social experiences that serve to enrich and develop EF skills (e.g., impaired JA, difficulties sustaining and shifting attention in social interactions, an impaired ability to modify social responses based on the context of the play or conversation). However, this issue is poorly understood due to a lack of systematic research, and further research is needed to clarify the role of early ASD symptomatology in the impaired development of EF skills (Yerys et al., 2007).

## 2.5 Theory of Mind (ToM)

Baron-Cohen et al. (1985) proposed that ASD stems from an inability to represent, conceptualize, and understand the mental states of others. According to this view, children with ASD are impaired in their ability to understand thought processes (e.g., beliefs, desires, goals, and intentions) as a means of predicting and explaining the behaviour of others, and conceptualize that the mental states of others may differ from their own. As an ability to represent and infer the mental states of others underlies many social and communicative interactions, a number of theorists have suggested that impairments in the development of mental-state understanding may be central to understanding the symptomatology associated with ASD (Baron-Cohen et al., 1985; Happé, 1995; Schlinger, 2009).

Consistent with this position, the development of behaviours that require perspective taking skills are impaired in children with ASD, including the use of mental-state terms such as ‘thinking’, ‘knowing’, and ‘guessing’ in their speech (Klin, 2000; Ziatas, Durkin, & Pratt, 1997), pragmatic language skills (Boucher, 2003; Volden et al., 2009), and JA (Carpenter et al., 2002; Dawson et al., 2002; 2004; Landa et al., 2007; Leekam & Ramsden, 2006).

### *2.5.1 The Development of ToM in TD Infants and Children*

The emergence of mental-state understanding in TD children follows a predictable developmental sequence (Pons, Harris, & de Rosnay, 2004; Wellman & Liu, 2004). Early foundations for mental-state understanding can be identified in infancy, with infants demonstrating an understanding of intentional actions by 9 to 18 months of age (Behne, Carpenter, & Tomasello, 2005; also see Olineck & Poulin-Dubois, 2005), and an understanding of another person’s visual experience by 12 to 18 months of age (Meltzoff & Brooks, 2008; Tomasello & Haberl, 2003). By 4 years of age, TD children begin to understand that their behaviour and the behaviour of others is determined by what they know, think, and believe. They also learn that their mental states may be different from those of others, and that people’s beliefs may be true or false (Schlinger, 2009; Wellman, Cross, & Watson, 2001). By 5 years of age, this understanding extends to emotions, with TD children understanding that people’s emotions are also influenced by their beliefs, knowledge, and thoughts (Pons et al., 2004).

### *2.5.2 Assessment of ToM*

ToM is typically assessed using a task in which the child is required to distinguish between the reality of a situation, and how it might be incorrectly represented in the mind of another person. Successful performance on ToM tasks thus requires the child to predict what a third person will believe to be true, which may differ from what the child knows to be true, and then predict the behaviour of the third person based on this understanding. First-order ToM requires making an attribution about the beliefs of one person, and predicting their actions based on their beliefs.

Second-order ToM requires an understanding of embedded mental states, and making an attribution about what a second person thinks a third person believes (e.g., he thinks that she thinks). In TD children, second-order metarepresentations emerge at a mental age of approximately 6 to 8 years (Kaland, Callesen, Moller-Nielsen, Mortensen, & Smith, 2008).

Two commonly used tasks to assess first-order ToM are the location change (Wimmer & Perner, 1983) and unexpected contents (Perner, Leekam, & Wimmer, 1987) tasks. In the location change task, a sequence of events is acted out with props and two dolls named Sally and Anne (Baron-Cohen et al., 1985). In the scenario, Sally and Anne are playing with a marble. Sally places the marble in the basket and leaves the scene. While she is gone, Anne retrieves the marble from the basket and places it inside the box. Sally then returns to the scene, and participants are asked where she will look for the marble. In the unexpected contents task, known as the ‘Smarties task’ (Perner et al., 1987), participants are shown that a box of Smarties contains pencils and not Smarties. They are then asked what someone else, who has not seen the pencils inside the Smarties box, would think was inside the box prior to opening it.

### *2.5.3 Research Examining ToM in ASD*

A number of studies have supported the ToM hypothesis of ASD, demonstrating that children with ASD are significantly impaired in their performance on ToM tasks relative to ID and TD children (Baron-Cohen et al., 1985; Happé, 1994; Kaland et al., 2008; Klin, 2000; Wellman et al., 2001). On the basis of these findings, deficits in ToM have become an explanatory theory for the major symptoms of ASD, particularly within the domain of social and communication skills. In a well documented study, Baron-Cohen et al. (1985) used a first-order unexpected transfer task (Wimmer & Perner, 1983) to assess the ToM understanding of 20 children with ASD (Mean CA = 11.11 years), 14 children with Down Syndrome (Mean CA = 10.11 years), and 27 TD preschool children (Mean CA = 4.5 years). Based on the finding that 80% of the participants with ASD were not able take account of the dolls’ false belief and accurately predict where she would look for the

marble, Baron-Cohen et al. (1985) concluded that children with ASD were impaired in understanding the mental states of others. More recently, Lind and Bowler (2009) examined whether 48 children and adolescents with ASD (Mean CA = 10.17 years) and 48 TD or ID children and adolescents (Mean CA = 9.28 years) differed in their performance on an unexpected contents task. Groups were matched on CA and verbal ability. Results indicated that participants with ASD were significantly impaired in their ability to infer the mental state of the protagonist, and predict her actions based on this belief, relative to TD participants and those with an ID.

Other studies have demonstrated that some children with ASD can pass first-order ToM tasks, however, they are significantly impaired in passing second-order ToM tasks (Baron-Cohen, 1998), advanced tasks that tap into complex language and face processing abilities (Heavy, Phillips, Baron-Cohen, & Rutter, 2000; Kaland et al., 2008; Kleinman, Marciano, & Ault, 2001; Roeyers, Buysse, Ponnet, & Pichal, 2001), and other complex metacognitive skills such as inferring bluff (Happé, 1994). Baron-Cohen (1989) presented children with ASD (Mean VMA = 12.2 years), children with Down Syndrome (Mean VMA = 7.5 years) and TD children (Mean CA = 7.5 years) with a second-order ToM task (Perner & Wimmer, 1985). The results indicated that while 90% of TD children and 60 % of the children with Down syndrome successfully inferred the false belief of the protagonist, none of the children with ASD demonstrated complex mental-state understanding. Baron-Cohen (1989) concluded that while children with ASD may develop the ability to make more simplistic, first-order metarepresentations, their understanding of mental states is rudimentary, with difficulties forming more complex, second-order metarepresentations persisting into adulthood. In a recent study, Kaland et al. (2008) examined the advanced ToM capabilities of 21 individuals with AsD (Mean CA = 15.9 years) and 20 TD individuals (Mean CA = 15.6 years) matched on CA. Participants were presented with first and second-order ToM tasks, and three advanced ToM tasks requiring the interpretation of mental-state information from static pictures of eyes (The Eyes Task: Baron-Cohen, Wheelright, Hill, Raste, & Plumb, 2001; Baron-Cohen, Wheelright, Spong, Scahill, & Lawson, 2001) and mentalistic vignettes (The Strange

Stories task: Happé, 1994; The Stories from Everyday Life: Kaland et al., 2002). Results indicated that while the majority of participants with ASD successfully passed the standard first and second-order ToM tasks, they were significantly slower, and less accurate at interpreting the advanced mentalistic content from static eyes and stories than TD participants.

The finding that children with ASD perform more poorly than TD children on assessments of ToM supports the notion that these individuals are impaired in their ability to understand the mental states of others. However, questions regarding the universality of ToM impairments in ASD have been raised due to a considerable number of children with ASD with average or above average intelligence passing both first-order and more complex ToM tasks; albeit at a later stage of development than TD children (Bowler, 1992; Dissanayake & Macintosh, 2003; Kaland et al., 2008; Peterson, Slaughter, & Paynter, 2007; Senju, Southgate, White, & Frith, 2009).

To account for these findings, several theorists have proposed that the development of ToM is delayed in individuals with ASD. This notion was supported in a longitudinal study by Steele, Joseph, and Tager-Flusberg (2003). In this study 57, 4- to 14-year-old children with ASD were presented with a series of nine developmentally sequenced tasks during an initial assessment session (Mean CA = 91.7 months) and then one year later (Mean CA = 105.3 months). All of the tasks assessed an aspect of mental-state understanding and ranged in complexity from pretence and desire tasks, to tasks assessing second-order false belief and moral reasoning. The results showed that all participants with ASD were considerably delayed in understanding ToM relative to CA-matched TD participants. However, there was a substantial development in their mental- state understanding over time, with an improvement observed for the majority of participants. A small number of the older, more able participants with ASD additionally developed the ability to pass the most complex assessments of mental-state understanding.

#### *2.5.4 Language and ToM Development*

Several researchers have proposed that when children with ASD successfully pass ToM

tasks, they do so via the use of compensatory, cognitive or linguistically-mediated strategies (Frith & Frith, 2003; Frith, Happé, & Siddons, 1994; Kaland et al., 2008; Steele et al., 2003).

Specifically, while TD children rely on social intuition and insight to pass ToM tasks, the mental-state understanding of children with ASD may be mediated by problem solving and logical reasoning (Bowler, 1992; Happé, 1994; Tager-Flusberg, 2000b), or language skills (Fisher, Happé, & Dunn, 2005; Steele et al., 2003; Tager-Flusberg & Joseph, 2005). In support of this notion, a number of previous studies have established a relationship between cognitive abilities and performance on ToM tasks for individuals with ASD (Frith et al., 1994; Kaland et al., 2008). Functional neuroimaging studies have also demonstrated that areas of the brain associated with general problem solving are activated in adults with ASD when completing ToM tasks, while neural regions associated with the social cognitive network (e.g., medial prefrontal cortex and temporoparietal junction) are activated for TD adults (Frith & Frith, 2003).

Other studies have established a relationship between language skills and performance on ToM tasks for both children with ASD (Adrian, Clemente, & Villanueva, 2007; Fisher et al., 2005; Lind & Bowler, 2009; Paynter & Peterson, 2010; Steele et al., 2003; Tager-Flusberg & Joseph, 2005) and TD children (Hale & Tager-Flusberg, 2003; Harris, de Rosnay, & Pons, 2005; Lohmann & Tomasello, 2003; Paynter & Peterson, 2010). In particular, Tager-Flusberg (2000b) proposed that understanding a form of syntax known as complementation is necessary for the development of a metarepresentational ToM (de Villers & Pyers, 2002). Syntactic complementation allows for tensed propositions to be embedded under a verb, with verbs of communication (e.g., “said”, “told”) or verbs of mental states (e.g., “thought”, “knew”) able to take sentential complements (e.g., “He said *he was going shopping* but he really went to the movies” or “He thought *there were smarties in the box*, but there were really pencils”). In support of this notion, Tager-Flusberg and Joseph (2005) reported that an understanding of semantics and complementation were the most significant predictors of ToM ability in children with ASD. Pons, Lawson, Harris, and de Rosnay (2003) also examined the relationship between language skills and emotional understanding in 80

TD children aged from 4 to 11 years of age, divided into four age groups: 4 to 5 years (Mean CA = 4.9 years), 6 to 7 years (Mean CA = 6.8 years), 8 to 9 years (Mean CA = 8.11 years) and 10 to 11 years (Mean CA = 10.11 years). The results indicated that children's emotional understanding was significantly correlated with their language skills, even when the effect of CA was controlled for. In an earlier study, Astington and Jenkins (1999) longitudinally examined the respective contributions of syntax and semantics to the development of ToM understanding in 59, 3-year-old children on three occasions over a 7-month period. The results indicated that language ability significantly predicted improvements in ToM performance. They further reported that syntactic knowledge, and not semantic knowledge, was significantly related to ToM understanding.

The link between the development of mental-state understanding and language ability in TD children is further supported by a relationship between maternal-child discourse about mental states, and ToM (de Rosnay, Pons, Harris, & Morrell, 2004; Ruffman, Slade, & Crowe, 2002). Several studies have established that the maternal use of mental-state terms such as 'think,' 'know,' and 'hopes' predicts later false belief understanding and the understanding of belief-based emotions in 3- to 6-year-old TD children (de Rosnay et al., 2004; Ruffman et al., 2002). Several researchers have also proposed that language-based interventions can improve children's mental-state understanding, with conversations about what people might say, think, know, and believe, significantly improving the ToM performance of 3-year-old TD children (Hale & Tager-Flusberg, 2003; Lohmann & Tomasello, 2003).

If TD children use social understanding to solve ToM tasks while children with ASD rely on cognitive or linguistically-mediated strategies, then the relationship between language or cognitive skills and performance on ToM tasks should be significantly stronger for individuals with ASD than other group of individuals. However, the extent to which the role of language in the development of mental-state understanding differs for TD children and those with ASD is unclear. Most studies examining the relationship between language and ToM task performance in children with ASD failed to conduct within-group analyses to ascertain whether the relationship between

language skills and ToM performance differed for children with ASD and TD children (Paynter & Peterson, 2010; Tager-Flusberg, 2000b). Other studies failed to employ appropriate control groups to address this question (Tager-Flusberg & Joseph, 2005).

However, recent studies have supported the notion that children with ASD use compensatory, linguistically-mediated strategies to pass ToM tasks. Kaland et al. (2008) found a significant correlation between VIQ and scores on advanced ToM tasks requiring the interpretation of mental-state information from mentalistic vignettes for children with ASD, but not for TD children. Similarly, Lind and Bowler (2009) examined the relationship between performance on a location change task and a syntactic complementation task in 48 children and adolescents with ASD (Mean CA = 10.17 years) and 48 TD or ID children (Mean CA = 9.28 years) matched on CA and verbal ability. The relationship between performance on an unexpected contents task and a syntactic complementation task in 53 children and adolescents with ASD (Mean CA = 9.17 years) and 53 TD or ID children (Mean CA = 8.81 years) matched on CA and verbal ability was also examined. Results indicated that there was a significant correlation between performance on the location change task and syntactic complementation for participants with ASD, but not for other groups. The relationship remained significant when VMA was controlled for. While the relationship between the unexpected contents task and syntactic complementation was significant for all groups of participants, these relationships did not remain significant when VMA and CA were controlled for. Lind and Bowler (2009) attributed the different results for the location change and unexpected contents tasks to the different cognitive and linguistic demands of the tasks, and concluded that syntactic complementation may allow individuals with ASD to pass location change tasks in the absence of mental-state understanding.

#### *2.5.5 Summary of Research Examining ToM in ASD*

Taken together, research studies examining the ToM hypothesis of ASD have shown that a significant proportion of individuals with ASD are impaired in their ability to understand beliefs, desires, goals, and intentions as a means of predicting and explaining behaviour in others.



Impairments in ToM have been established for first-order, second-order and more complex mental-state representations.

However previous research studies also indicated that the failure to pass false belief tasks is not a consistent feature of ASD symptomatology. While children who pass first-order ToM tasks often fail more complex, second-order false-belief tasks, or other advanced ToM tasks that require complex language and face processing abilities, a proportion of individuals with ASD are able to pass even the most complex ToM tasks at a significantly later developmental stage than TD children (Dissanayake & Macintosh, 2003; Senju et al., 2009). The ability to understand the mental states of others appears to improve with development for both children with ASD and TD children (Bowler, 1992; Ozonoff et al., 1991), and may be mediated by other variables such as language and cognitive skills (Harris et al., 2005).

#### *2.5.6 Limitations of the ToM Hypothesis of ASD*

There are several limitations with the ToM hypothesis of ASD symptomatology. First, the ToM hypothesis does not account for some of the earliest ASD symptomatology, with a number of social and communicative impairments evident in children with ASD considerably earlier in development than ToM abilities emerge in TD children. These include decreased responsivity to social stimuli, reduced response to name, poor eye-contact and impaired JA (Clifford et al., 2007; Maestro et al., 2005; Osterling et al., 2002). The ToM hypothesis also fails to account for other features of ASD symptomatology, such as overly focused attention to objects or activities to the exclusion of other stimuli, less flexibility and responsiveness to cues in their environment, restricted patterns of interests or activities, resistance to change, and a relative strength in visual processing (APA, 2000; Tager-Flusberg, 2007).

Second, the ability to pass ToM tasks may be mediated by other variables such as EF skills (Peterson, Garnett, Kelly, & Attwood, 2009). A relationship between the development of ToM and EF skills has been established, with performance on ToM tasks related to planning, flexibility, WM

and inhibition in children with ASD and CA-and-IQ-matched TD children (Carlson, Mandell, & Williams, 2004; Carlson & Moses, 2001; Carlson et al., 2002; Joseph & Tager-Flusberg, 2004; Pellicano, 2007). While the direction of causality between EF and ToM development is not fully understood (Carlson et al., 2004), previous research suggests that EF is an important factor in the development of children's mental-state understanding (Carlson et al., 2004; Carlson & Moses, 2001).

Third, impairments in ToM are not specific to ASD, with deficits in ToM reasoning observed in non-signing deaf individuals relative to deaf native signers and TD individuals. Furthermore, these deficits are still observed when tasks are modified to account for difficulties understanding the language of the task by using non-verbal (Figueras-Costa & Harris, 2001) or pictorial (Woolfe, Want, & Siegal, 2002) tasks, or when potentially confounding factors such as NVMA, syntax ability and EF skills are controlled for (Peterson & Siegal, 2000; Peterson, Wellman, & Liu, 2005; See Courtin & Melot, 2005 for a review). While these findings have been related to the role of language in the development of ToM, the different social-emotional developmental trajectory for deaf children and those with ASD suggests that impairments in ToM alone are not sufficient to account for ASD symptomatology.

Finally, it has been proposed that ToM tasks lack ecological validity, and measure aspects of social cognition in clinical settings which have little relevance to social functioning in a naturalistic environment. While a large number of children with ASD are able to pass ToM tasks, they lack social 'intuition' in their social interactions with others (Dissanayake & MacIntosh, 2003; Frith et al., 1994). In an early study, Frith et al. (1994) examined whether performance on a standard false-belief task was related to adaptive social behaviour as assessed by the Vineland Adaptive Behavior Scales (VABS; Sparrow, Balla, & Cicchetti, 1984) in 24, 7 to 19-year-old individuals with ASD and language-matched ID and TD children. The results revealed that, for all groups of participants, there was no difference in the social adaptive behaviours of children who passed or failed ToM tasks. The lack of relationship between performance on ToM tasks and

adaptive social functioning remained when the relationship between performance on false-belief tasks and a subset of items from the VABS (Sparrow et al., 1984) that reflected the real world application of mental-state understanding (e.g., ‘chooses appropriate presents,’ ‘refrains from statements that might embarrass’ or ‘responds to hints and indirect cues in conversation’) were examined. The results revealed that only 3 of the 8 children with ASD who passed the ToM tasks, demonstrated any of the relevant social items in their everyday behaviour. Frith et al. (1994) concluded that only a minority of children with ASD who are able to pass ToM tasks, apply social cognitive understanding in their everyday social interactions with others. These results were replicated in a more recent study by Dissanayake and MacIntosh, (2003) who failed to find a relationship between false belief scores and scores on the social and communication subscales of the VABS (Sparrow et al., 1984) for 39 children with ASD.

However, other researchers have found evidence of a relationship between ToM performance and social functioning in the naturalistic setting, giving some validity to the real world application of ToM assessments. Tager-Flusberg (2003) examined whether there was a relationship between a series of developmentally sequenced ToM tasks (including false belief understanding and moral judgements) and socialization scores on the VABS (Sparrow et al., 1984), and severity of social and communication impairment on the Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, DiLavore, & Risi, 2002). Sixty-nine, 4- to 14-year-old children with AD participated in the study. Results revealed that there was a relationship between performance on ToM tasks and VABS (Sparrow et al., 1984) and ADOS (Lord et al., 2002) scores, even when the effects of CA, IQ and language skills were controlled for.

However, the extent to which the VABS (Sparrow et al., 1984) is a good measure of mental-state understanding in real world situations is questionable (Peterson et al., 2009). As the items on the VABS (Sparrow et al., 1984) span a wide age range from infancy to 90 years, a number of items reflect behaviour that emerges considerably earlier or later than the emergence of

ToM understanding in TD children. The large number of unrelated and developmentally incongruous items may thus have reduced the extent to which this scale was related to ToM understanding in these studies (Peterson et al., 2009). Second, as the VABS (Sparrow et al., 1984) examines the presence or absence, but not the quality of social behaviours, it is possible that mental-state understanding may be more closely related to qualitative differences in the social behaviour of individuals with ASD, rather than the presence or absence of the behaviour per se (Peterson et al., 2009).

To address these issues, Peterson et al. (2009) examined whether there was a relationship between performance on ToM assessments in the clinical setting, and qualitative and quantitative teacher ratings of participants' mental-state understanding in their conversations and social interactions in the naturalistic setting. Fifteen children with ASD (Mean CA = 9.61 years), and 10 TD children (Mean CA = 6.06 years) participated in the study. The results indicated that for both children with ASD and TD children, those who failed the ToM tasks exhibited more mindreading difficulties in their everyday life than those who passed. However, contrary to expectations, the results also indicated that children with ASD who passed the ToM tasks were significantly more impaired in understanding the mental states of others in everyday social interactions than TD children who failed the ToM tasks.

Taken together, these findings indicate that while ToM assessments may have some real-world applicability for children with ASD, they are not always reflective of children's social understanding in their naturalistic social interactions with others. Peterson et al.'s (2009) finding that children with ASD who pass ToM tasks are less able to apply mindreading skills in their everyday interactions and conversation than TD children who fail ToM tasks, may indicate that early social interactions for TD children may promote the development of social cognitive abilities that operate independently of their performance on clinically-based ToM tasks. While the exact relationship between performance on ToM tasks and the real-world application of social cognition

remains unclear for both children with ASD and TD children, it is apparent that, for children with ASD, the ability to pass ToM does not in itself guarantee the integration of these skills into their socio-communicative interactions with others.

Other researchers have demonstrated that ToM ability in the clinical setting does not mean that children with ASD spontaneously attribute the mental states of others in the naturalistic social setting. Senju et al. (2009) examined whether adults with AsD who exhibit an intact ability to understand the mental states of others on explicit ToM tasks, spontaneously mentalize by using anticipatory eye movements to predict an actor's behaviour based on an understanding of his / her false belief. Participants with AsD (Mean CA = 36.8 years) did not differ from CA-and-IQ-matched TD participants (Mean CA = 39.6 years) on a series of first-order ToM tasks (Sally-Anne Task: Baron-cohen et al., 1985; The Smarties Task: Perner et al., 1987; Interpretational false belief: Luckett, Powell, Messer, Thornton & Schulz, 2002; Belief-emotion and real-apparent emotion : Wellman & Liu, 2004), second-order ToM tasks (Ice cream van story: Perner & Wimmer, 1985; Coat story: Bowler, 1992) or a strange stories task (Fletcher et al., 1995). However, they were significantly less likely than TD participants to spontaneously predict the actions of the protagonist and make an anticipatory eye movement to the location where the protagonist should look for an object through taking account of his / her false belief. Senju et al. (2009) concluded that while participants with AsD are able to complete explicit ToM tasks, they fail to spontaneously infer the mental states of others in the naturalistic setting.

## 2.6 Chapter Summary and Conclusions

In this chapter, the three most prominent psychological theories of ASD: WCC, EF and ToM were overviewed. According to the WCC theory, ASD symptomatology stems from a local processing bias and difficulties processing stimuli on a global level. A review of the literature revealed that while the notion of a local processing bias is well supported in the research, there are

conflicting findings regarding whether global processing is impaired or intact in ASD. The EF theory states that ASD symptomatology stems from impaired goal-directed behaviour, such as disengaging and shifting attention, inhibiting a pre-potent response, memory, and planning skills. While the findings from previous research studies are mixed, evidence suggests that individuals with ASD are impaired in some aspects of EF, particularly when required to demonstrate complex, higher-order cognitive skills. Finally, the ToM theory proposes that ASD symptomatology stems from an inability to represent, conceptualize and understand the mental states of others. A review of the literature demonstrated that a significant proportion of individuals with ASD perform poorly on tasks that require ability to predict the behaviour or emotions of a protagonist through taking account of their false belief. However research findings in this area are mixed, with a significant proportion of individuals with ASD able to pass ToM tasks, albeit at a later age than TD children.

Individually, these theories fail to account for all aspects of ASD symptomatology. However, Hill and Frith (2003) suggested that the theories of ASD need not be viewed as competitive, with each theory attempting to explain a different facet of ASD symptomatology. Despite this, for all theories, small differences in task methodology and administration (e.g., different tasks or task instructions, control groups, and matching procedures) and differences in the specific characteristics of participants (e.g., age, cognitive ability, and severity of ASD symptomatology), significantly impacts on the research findings. This suggests that the development and demonstration of global processing, EF, and ToM skills may be mediated by other aspects of development. Additionally, the cognitive impairments central to these theories are neither universal nor specific to individuals with ASD, and generally emerge at a significantly later age than the early-emerging symptomatology that is central to a diagnosis of ASD. Thus the extent to which these cognitive impairments can account for the symptomatology that is evident prior to 18 months of age (e.g., a lack of JA, eye-contact, and response to name; Osterling & Dawson, 1994; Osterling, Dawson, & Munson, 2002) is limited.

In an effort to better account for the earliest-emerging symptomatology in individuals with ASD, several researchers have focused on the importance of social engagement in infancy. Research examining early-childhood development has consistently demonstrated that TD infants are attuned to the social world, with social stimuli holding more salience than any other environmental stimuli. This preparedness to process, interpret, and find meaning in social stimuli may underlie the development of more complex social and cognitive skills. In support of this notion, the earliest-emerging symptomatology associated with ASD is indicative of reduced social engagement.

However, it is unclear whether the reduced tendency to attune to social stimuli in individuals with ASD stems from the reduced salience of social stimuli, whether it is related low-level attentional problems and difficulties disengaging and shifting attention rapidly across stimuli, or whether it stems from a combination of these two factors. An impaired ability to disengage and shift attention between visual stimuli, coupled with difficulties attending to the whole rather than part, would exacerbate a reduced tendency to orient to social stimuli. This would lead to the symptomatology associated with ASD, including deficits in social behaviour and impairments in the development of higher-order ToM and EF skills. The research related to low-level attentional impairments in shifting and disengaging attention, and research examining the notion of a specific impairment orienting attention to social stimuli will be reviewed in Chapters 3 and 4 respectively.

## CHAPTER 3: NON-SOCIAL ATTENTION

### 3.1 Chapter Overview

In this chapter, the development of non-social orienting in TD infants and children is overviewed, and the literature pertaining to disengaging, shifting and reorienting attention to non-social stimuli in individuals with ASD is critically evaluated.

### 3.2 Attention

The environment contains countless sources of information for perceptual and cognitive processing. Despite this, successful adaptation requires that a restricted number of stimuli are selected at any one time for further processing (Bowler, 2007; Enns & Burack, 1997; Schoch et al., 2004). According to Englemann and Pessoa (2007), two systems are necessary for goal-directed behaviour: (i) ‘attention,’ or the mechanisms responsible for prioritizing and selecting behaviourally relevant stimuli while simultaneously suppressing irrelevant stimuli (Berger, Henik, & Rafal, 2005; Bird, Catmur, Silani, Frith, & Frith, 2006; Schoch et al., 2004) and (ii) the ‘reward system,’ which is necessary for establishing behavioural goals and motivating behaviour (Englemann & Pessoa, 2007). While a clear and universally accepted definition of attention has not yet appeared in the literature, most theorists agree that it is a multifaceted construct comprising of several distinct processes. Central to the concept of attention is the ability to select stimuli for processing, focus on a task or stimulus while filtering out distractions, sustain attention or maintain the focus of attention and vigilance over a period of time, and shift or move the focus of attention efficiently across stimuli. ‘Attention’ also involves the ability to efficiently receive and process information while allocating the necessary cognitive resources for goal-directed behaviour (Mirsky, Anthony, Duncan, Ahearn, & Kellam, 1991; Posner, Petersen, Fox, & Raichle, 1988).



### 3.3 Attention in ASD

The restrictive properties of attention play a critical role in information processing and the development of higher-order cognitive operations. Consequently, attentional impairments have been a key focus of research in ASD. Behaviours indicative of deficits in basic attentional processes in individuals with ASD include a tendency to focus on minor or irrelevant aspects of cues rather than scanning their environment for relevant information, a propensity for becoming overly focused on objects or activities to the exclusion of other stimuli, less flexibility and responsiveness to cues in their environment, restricted patterns of interests or activities, and a resistance to change. In the social sphere, individuals with ASD also exhibit unusual gaze behaviour, fail to use gaze to share attention and regulate behaviour, and often fail to respond to others' attempts to gain their attention (APA, 2000; Bowler, 2007; Dawson et al., 1998; 2004; Gomot, Belmonte, Bullmore, Bernard, & Baron-Cohen, 2008; Lam, Bodfish, & Piven, 2008). Several of the prominent symptoms of ASD are therefore suggestive of an early-developing attentional impairment.

Consistent with clinical observations, a number of researchers have sought to identify whether attentional impairments underlie the broad range of symptoms associated with ASD. It has been proposed that early-occurring attentional impairments may underlie many of the clinical features of ASD, and impede the development of complex cognitive operations and social skills. These include the development of language, social behaviour, JA, social cognition, and other goal-directed behaviours (Bryson, Landry et al., 2004; Courchesne et al., 1994; Dawson et al., 2004; Elsabbagh et al., 2009; Kawakubo et al., 2007; Landry & Bryson, 2004). Specific theories have considered impairments in selecting stimuli for further processing (Kaland, Smith, & Mortensen, 2008), sustaining (Corbett & Constantine, 2006; Johnson et al., 2007), disengaging (Elsabbagh et al., 2009; Landry & Bryson, 2004; Zwaigenbaum et al., 2005), shifting or moving (Courchesne et al., 1994; Harris, Courchesne, Townsend, Carper, & Lord, 1999; Renner, Klinger, & Klinger, 2006;

Townsend et al., 1999; Zwaigenbaum et al., 2005) and reengaging attention (Kawakubo, Maekawa, Itoh, Hashimoto, & Iwanami, 2004; Kemner, Verbaten, Cuperus, Camfferman, & Engeland, 1998; Van Der Geest, Kemner, Camfferman, Verbaten, & Van Engeland, 2001) as potential impairments.

Overall, research suggests that individuals with ASD are unimpaired on attentional tasks that do not require the rapid shifting of attention (Belmonte, 2000; Bird et al., 2006; Courchesne et al., 1994). The ability to maintain focus on a selected activity or stimulus for an extended period of time, at least in certain contexts, is reportedly intact in children and adults with ASD (Johnson et al., 2007; Liss et al., 2001; O’Riordan et al., 2001; Pascualvaca et al., 1998). Evidence of overly-focused attention, perseverative behaviours, and difficulties disengaging and shifting attention in individuals with ASD, supports this notion (Gomot et al., 2008; Landry & Bryson, 2004; Mann & Walker, 2003; Renner et al., 2006).

In contrast, specific deficits disengaging, shifting and reengaging attention have been widely documented (Courchesne et al., 1994; Harris et al., 1999; Landry & Bryson, 2004; Renner et al., 2006; Townsend et al., 1999). Together, these sequential processes are referred to as orienting attention (Posner & Peterson, 1990; Posner et al., 1988). Orienting attention encompasses the ability to rapidly alter the focus and scope of attention among different sensory modalities and locations in response to environmental or internal changes. It is a critical component of integrating and interpreting the large range of stimuli in one’s environment (McConnell & Bryson, 2005). Deficits in all three areas of selective orienting (i.e., disengaging, shifting and reengaging attention) have been implicated in ASD.

### 3.4 Orienting Attention

‘Orienting Attention’ refers to the spontaneous alignment of attention upon the detection of a novel or salient stimulus (Sergeant, 2001). Stimuli selected for attention are determined by a number of factors. Semantic and contextual information, personal interests, goals, preferences, and

the visual salience of stimuli help prioritize the focus of attention (Brockmole & Henderson, 2005; Hollingworth & Henderson, 2000; Werner & Thies, 2000). Information that is unexpected, informative, situationally significant, or of personal interest, is therefore more likely to be attended to (Brockmole & Henderson, 2005; Hollingworth & Henderson, 2000). The ‘orienting’ response is a necessary precursor for focused attention and further information processing (Sergeant, 2001).

Posner et al. (1988) proposed that the orienting response is comprised of three operations, namely, the ability to disengage attention from an object or location, move or shift attention in space, and then reengage attention to a new object or location. Upon reengaging attention, information processing resources are allocated to the new target or location. Impairments in one or more of these components can result in impairments orienting attention. Behaviours such as a failure to orient to one’s name, repetitive behaviours, a preoccupation with specific stimuli or thoughts, and difficulties transitioning between tasks or activities have been attributed to difficulties orienting attention.

### 3.5 Exogenous and Endogenous Orienting

External sources of stimuli and internal goals constantly compete for the resources of the visual orienting system (Berger et al., 2005). Visual attention may thus be triggered exogenously (automatically) or endogenously (voluntarily). Exogenous attention refers to attention that is automatically drawn to a specific location by a sensory event. Exogenous orienting is stimulus driven, involuntary, rapid, short in duration, and unaffected by co-occurring cognitive demands (Abrams & Law, 2000; Bartolomeo & Chokron, 2002). When attention is engaged exogenously, other, less significant events, are ignored (Abrams & Law, 2000). In contrast, endogenous attention is voluntarily initiated in response to internally generated goals (Berger et al., 2005), and may be triggered by task demands, instructions, and symbolic cues (Iarocci, Enns, Randolph, & Burack, 2009). Endogenous orienting requires mental effort, takes longer to complete, and is longer lasting

than exogenous orienting (Brodeur, Trick, & Enns, 1997; Jonides, 1981). It is also susceptible to interruption from other cognitive demands (Jonides, 1981).

Exogenous and endogenous orienting differ in their functional impact on behaviour (Iarocci et al., 2009) and develop along different trajectories (Akhtar & Enns, 1989; Brodeur & Boden, 2000). They are also thought to be mediated by different neural structures. Exogenous orienting is said to involve the superior colliculus and parietal lobe, while endogenous orienting reportedly involves the frontal lobes of the brain (Corbetta & Shulman, 2002; Hopfinger, Buonocore, & Mangun, 2000; Johnson, 2002; 2005). Despite the fundamental differences between exogenous and endogenous orienting, they need to be flexibly coordinated and integrated in order to meet internally driven goals while maintaining awareness of the external environment (Iarocci et al., 2009).

### 3.6 Typical Development of Attentional Orienting

The emergence of early attentional skills in TD infants follows a predictable sequence of development (Atkinson, 1984; Johnson, 1990). In the first days of life, infants demonstrate an ability to orient attention towards salient environmental stimuli (Dannemiller, 2002; Ruff & Rothbart, 1996). At this stage of development, infants' attention is automatically drawn towards stimuli in the environment without mental effort or conscious awareness, and is 'captured' by visual features of the stimuli such as colour and degree of contrast (Atkinson, Hood, Wattam-Bell, & Braddick, 1992; Dannemiller, 2002). This early-developing ability to exogenously attend to objects and events in the environment is considered fundamental to survival (Iarocci et al., 2009).

Within the first few months of life, infants' attention is characterized by a tendency to fixate on stimuli for extended periods of time, and difficulties shifting their attention once engaged (Atkinson et al., 1992). This phenomenon is referred to as 'obligatory looking' (Johnson, 1990) or 'sticky fixation' (Hood, 1995). Researchers have suggested that 'obligatory looking' results from

the infants' inability to easily disengage and shift their focus of attention across stimuli (McConnell & Bryson, 2005).

At approximately 3 to 4 months of age, a significant transition in the development of attentional processes occurs. This period is characterized by greater attentional control and the elimination of 'obligatory looking'. Infants are able to disengage and shift their attention towards another stimulus (Hood & Atkinson, 1993; Johnson, Posner, & Rothbart, 1991; McConnell & Bryson, 2005). They also show an emerging ability to use 'cues' to facilitate shifts of attention to stimuli within their visual field (Hood, 1995). In the latter half of the first year of life, endogenous (i.e., controlled) attention processes emerge (Colombo & Cheatham, 2006; Hood, 1995; Ruff & Capozzoli, 2003; Ruff & Rothbart, 1996). Infants begin to show the ability to shift their attention voluntarily in response to internal goals and expectations (Gilmore & Johnson, 1995).

Research suggests that the manner in which infants orient to stimuli in their environment undergoes a significant transition in the first few months of life. The development of the ability to quickly and effortlessly disengage and shift attention across environmental stimuli marks the beginning of increased flexibility and control of attention. Exogenous orienting becomes increasingly rapid and efficient until approximately 6 years of age, when children and adults demonstrate similar levels of ability (Enns & Brodeur, 1989; Wainwright & Bryson, 2002). Endogenous orienting takes longer to develop, with flexible and voluntary control of attention gradually increasing with age. The ability to efficiently orient attention and discriminate between task relevant and irrelevant events and stimuli develops by approximately 8 years of age (Brodeur & Enns, 1997; Corbetta & Shulman, 2002; Goldberg, Maurer, & Lewis, 2001) and peaks by early-to-mid-adulthood (Enns & Brodeur, 1989).

Due to the significant development of attention processes in infancy and early childhood, and the possible role of attentional impairments in the psychopathology of ASD, researchers have

sought to examine the nature of attentional impairments in ASD. Of particular interest is whether impairments in the early-developing attentional skills of disengaging, shifting and reorienting attention might adversely affect the development of social skills, social cognition and other higher-order cognitive skills.

### 3.7 Orienting Impairments in ASD

The ability to attend to relevant stimuli, suppress attention to irrelevant stimuli, and rapidly alter the scope and focus of attention is critical for cognitive and social development. Difficulties disengaging and shifting attention may result in a fragmented, incomplete and incoherent comprehension of events. The issue of whether or not individuals with ASD are impaired in disengaging and rapidly reorganizing the scope of their attention in response to changes in incoming stimuli has received considerable research attention (Courchesne et al., 1994; Harris et al., 1999; Iarocci & Burack, 2004; Landry & Bryson, 2004; Renner et al., 2006; Townsend et al., 1999; Van der Geest et al., 2001).

#### 3.7.1 *Posner Spatial-Cueing Paradigms*

Many studies examining whether or not individuals with ASD are impaired in disengaging, shifting and reengaging attention to visual stimuli have utilized variants of Posner's (1980) spatial-cueing paradigm. In a Posner spatial-cueing task, participants are required to fixate on a central location on a computer screen. A locational cue is then presented, following which a short (e.g., 100 to 200ms) or long delay (e.g., 800 to 1000ms) is imposed. This delay is known as the cue-to-target delay. Following the delay, a target stimulus appears to the left or right side of the screen. The participant is required to press a button as quickly as possible upon detecting the target stimulus (Bowler, 2007; Landry, Mitchell, & Burack, 2009; Renner et al., 2006). The locational cue preceding the target stimulus may be valid, invalid or neutral. Valid cues indicate the correct location of the target stimulus. Invalid cues indicate the incorrect location of the target stimulus.

Neutral cues do not give any information regarding the location of the target stimulus (Bowler, 2007; Landry et al., 2009; Renner et al., 2006).

Depending on the nature of the locational cue presented, attention can be directed to the spatial location automatically (i.e., exogenously) or voluntarily (i.e., endogenously). Abrupt onset peripheral cues, such as a flash of light, are typically used to direct attention exogenously. These cues are presented in the one of the locations where the target could appear, and elicit an attention shift based on by the physical properties of the cue. In contrast, symbolic cues, such as an arrow pointing to the left or right side of the screen, are typically used to direct attention endogenously. These cues are presented in the centre of the screen and require the participant to cognitively interpret the cue and voluntarily shift attention to the cued location (Bowler, 2007; Landry et al., 2009; Renner et al., 2006). While attention shifts can occur overtly (i.e., with observable eye and head movements) or covertly (i.e., without an observable eye or head movement), Posner spatial-cueing paradigms measure covert attention using indirect measures of stimulus detection (e.g., pressing a button).

### *3.7.2 Research using Posner Cueing Paradigms in ASD*

A number of studies have utilized Posner spatial-cueing paradigms to examine exogenous and endogenous orienting in individuals with ASD. Three major findings have emerged from these studies, providing evidence of impaired visuospatial orienting in ASD. First, several researchers have reported that when the target stimulus is preceded by a valid cue, participants with ASD show an impaired ability to shift and refocus attention when given a short amount of time to do so (e.g., in the short-cue-target delay conditions of 100 to 200ms), relative to control subjects. However, when given more time (e.g., long cue-to-target delays of 800 to 1000ms), they show an intact ability to shift attention. These results have been observed in tasks requiring target detection (Harris et al., 1999; Townsend, Singer-Harris, & Courchesne, 1996; Townsend et al., 1999) and more complicated target discrimination (Renner et al., 2006; Townsend et al., 1999), using both

measures of response time (Harris et al., 1999; Townsend et al., 1996; 1999; Wainwright-Sharp & Bryson, 1993) and response accuracy (Renner et al., 2006; Townsend et al., 1999). Second, TD individuals respond more quickly to validly than invalidly cued targets in short cue-to-target delay conditions. This is referred to as the cue-validity-effect. However, participants with ASD fail to show faster RT's to validly than invalidly cued targets in this condition. Instead, participants with ASD do not differ in their RT's to validly and invalidly cued targets (Harris et al., 1999; Townsend et al., 1996; 1999; Wainwright-Sharp & Bryson, 1993). Third, while participants with ASD show cue-validity-effects (i.e., differences in reaction times to validly versus invalidly cued targets) in the long cue-to-target delay condition, their cue-validity-effects are significantly larger than TD individuals. Participants with ASD are significantly slower to respond to invalidly versus validly cued targets in long cue-to-target delay conditions relative to TD participants (Harris et al., 1999; Renner et al., 2006; Townsend et al., 1996; 1999; Wainwright-Sharp & Bryson, 1993). When a significant discrepancy in the RTs to validly and invalidly cued targets is observed, a deficit in the ability to disengage attention is inferred.

In several studies examining visuospatial orienting in ASD, the target stimulus was preceded by centrally-presented-symbolic-cues (Renner et al., 2006; Wainwright-Sharp & Bryson, 1993), while other studies utilized abrupt-onset-peripheral-cues to direct attention (Harris et al., 1999; Iarocci & Burack, 2004; Renner et al., 2006; Townsend et al., 1996; 1999). While abrupt-onset-peripheral-cues are generally associated with exogenous orienting, the target stimulus was preceded by valid cues significantly more frequently than invalid or neutral cues in the majority of these studies (Harris et al., 1999; Renner et al., 2006; Townsend et al., 1996; 1999). As a result, a predictive relationship between the cue and location of the target was formed, resulting in a voluntary attention shift to the cued location due to the high probability that the target would appear in that location (Bowler, 2007; Decaix, Siéoff, & Bartolomeo, 2002; Iarocci & Burack, 2004). A number of theorists have proposed that when the cue-target relationship is meaningful or



predictive, endogenous processes are engaged. Thus, in studies where the target is validly cued on more than 50% of trials, conclusions regarding orienting impairments in ASD are limited to the volitional or endogenous aspects of orienting (Bowler, 2007; Decaix et al., 2002; Iarocci & Burack, 2004).

Using centrally-presented-symbolic-cues, Wainwright-Sharp and Bryson (1993) examined visuospatial orienting in 8 adolescents and adults with ASD (Mean CA = 20.4 years) and 11 neurotypical adolescents and adults (Mean CA = 20.6 years); groups were matched on CA. In this study, participants were presented with valid, invalid and neutral symbolic (arrow) cues for either 100 or 800ms, following which a target appeared in a peripheral location. Results indicated that while neurotypical participants consistently responded more quickly when targets were preceded by a valid cue than an invalid cue, participants with ASD failed to show faster RT's to validly cued targets in the short cue-to-target delay condition (100ms). In the long cue-to-target delay condition, individuals with ASD demonstrated a RT advantage on validly cued trials, however they were slower to shift and reorient their attention following an invalid cue. Wainwright-Sharp and Bryson concluded that individuals with ASD were slower to orient attention endogenously relative to TD control subjects, and were impaired in their ability to disengage and rapidly shift attention across stimuli following an invalid cue.

Using abrupt-onset peripheral cues, Townsend et al. (1999) examined attentional orienting in adults with ASD with developmental cerebellar abnormalities, adults with cerebellar damage acquired from tumor or stroke, and neurotypical adults. Two tasks were implemented in which a subgroup of participants participated: a spatial detection task, and a spatial discrimination task. The spatial detection task was a variation of Posner's spatial-cueing paradigm. In this task, participants' fixated on a central cross, following which a valid, invalid, or neutral locational cue was presented. Following the locational cue, a short (50 or 100ms) or long (800ms) delay was imposed prior to the presentation of the target stimulus (an asterix). Participants were required to

press a button as quickly as possible upon detecting the target stimulus. The spatial discrimination task, while similar in methodology to the spatial detection task, required participants to make a target discrimination. As in the detection task, participants were presented with valid or invalid peripheral cues, following which a short (100ms) or long (800 or 1200 ms) cue-to-target delay was imposed prior to the presentation of the target stimulus. In this task, however, the target stimulus was the letter 'E' presented in different spatial orientations (i.e., up, down, left, or right). The target stimulus was presented for 50ms before being obscured by another symbol. Subjects were required to use a joystick lever to indicate the direction of the target orientation (i.e., up, down, right, left). Response times and accuracy were recorded. The target stimulus was validly cued on 75% of trials, thereby establishing a predictive relationship between the cue and the location of the target stimulus. Results indicated that participants with ASD were slower to respond to the target stimulus on validly cued trials, and failed to benefit from valid versus invalid cues in the short cue-to-target delay condition relative to other groups of participants. In the long cue-to-target delay condition, however, participants with ASD showed an intact ability to orient attention to validly cued targets and showed the expected RT benefits of validly versus invalidly cued targets. However, they were significantly slower than control subjects to respond to targets following an invalid cue, indicating an impaired ability to disengage and move attention away from an incorrectly cued location. Townsend et al. (1999) concluded that participants with ASD were impaired in their ability to rapidly orient attention on tasks requiring both simple target detection and more complex target discrimination.

More recently, Iarocci and Burack (2004), examined exogenous orienting in 14 children with ASD (Mean CA = 11.6 years) and 14 TD children (Mean CA = 5.7 years) matched on MA. In this study, participants were presented with a valid, invalid or neutral sudden-onset-peripheral-cues (e.g., flashes of light) on a computer screen. Valid and invalid cues were presented with equal predictability, thereby ensuring automatic (i.e., exogenous) orienting of attention to the target

stimulus. The target stimulus appeared approximately 150 ms following the removal of the cue. On 50% of the trials, the target stimulus was flanked by distractors on both sides. Distractors consisted of four graphic symbols. The location of the cue preceding the target (i.e., valid, invalid or neutral), the location of the target stimulus, and the presence or absence of distractors were varied on each trial. Orienting and filtering skills were then assessed by comparing reaction times on trials with neutral, valid and invalid cues, and the presence or absence of distractors respectively. Results indicated that children with ASD did not differ from TD children on the effects of cue validity and distractors with short cue-to-target delays (i.e., 150ms). Both groups of participants demonstrated similar reaction times to valid versus invalid cues, and longer RT when distractors were presented in the visual field. Iarocci and Burack concluded that individuals with ASD were not impaired in their ability to rapidly orient attention to exogenous flash cues.

#### *3.7.2.1 Summary of Research using Posner Cueing Paradigms in ASD*

The research findings suggest that individuals with ASD are unimpaired in their ability to orient attention to external cues that elicit automatic or exogenous attention shifts (Iarocci & Burack, 2004); however they are impaired in orienting attention when the cue requires a cognitive interpretation of the cue or cue-target relationship, and a voluntarily attention shift (Bowler, 2007; Iarocci & Burack, 2004). The finding of impaired endogenous but not exogenous orienting is consistent with other research showing that participants with ASD are more impaired in higher than lower order cognitive processes (Iarocci & Burack, 2004; Minshew, Johnson, & Luna, 2001).

The failure to observe a RT advantage on validly cued targets for participants with ASD in the short cue-to-target delay condition has been interpreted as evidence of an impaired ability to rapidly interpret the meaning of the symbolic cue at the perceptual level (Burack, Enns, Stauder, Mottorn, & Randolph, 1997). However, other researchers have proposed that individuals with ASD are able to read cues as well as TD individuals, but are slower to prepare and execute a shift of visual attention in response to the cue (Landry et al., 2009; Wainwright-Sharp & Bryson, 1993).

This issue was examined in a recent study by Landry et al. (2009) who presented participants with ASD (Mean CA = 11.52 years) and CA-and-IQ-matched TD participants (Mean CA = 11.00 years) with a variant of Posner's spatial-cueing task. In this task, the length of exposure to non-predictive symbolic cues (arrows), and the response preparation time was varied. The authors predicted that if participants with ASD were impaired in rapidly interpreting the meaning of the symbolic cue, a RT advantage to validly versus invalidly cued targets would only be observed when the symbolic cue was presented for longer durations. Conversely, if individuals with ASD were impaired in planning and executing a response to the cue, then a RT advantage to validly cued targets would be observed in longer cue-to-target delay conditions regardless of the length of presentation of the cue. The results showed that individuals with ASD were unimpaired in their ability to rapidly interpret the meaning of the symbolic cue, however, were slower than control subjects to execute an attention shift in response to the cue. These findings are consistent with Elsabbagh et al. (2009), who reported that nine, 9- to 10-month-old infant siblings of children with ASD (SIBS-A) were significantly slower than CA-matched infants with no first or second degree relatives with an ASD, to form an expectation regarding the impending presentation of a centrally-cued target, and prepare a saccade towards the target.

Taken together, these findings support the notion of intact exogenous orienting and impaired endogenous orienting in ASD, and suggest that the impairment in responding to symbolic cues is at the level of response preparation and execution.

#### *3.7.2.2 Limitations of Research using Posner Cueing Paradigms in ASD*

Recent studies have questioned whether the central arrow cue utilized in endogenous visuospatial-cueing paradigms isolate volitional orienting, or measure a combination of exogenous and endogenous orienting. In particular, reflexive orienting in the direction of a symbolic cue, even when the cue does not predict the location of the target, has been observed (Ristic, Friesen, & Kingstone, 2002; Tipples, 2002). Ristic and Kingstone (2006; 2009) directly examined this issue

by measuring exogenous and endogenous orienting combined, and in isolation, with preschool-aged children and adults. To do this, RT's to a target preceded by predictive arrow cues, non-predictive arrow cues, a predictive shape, and a non-predictive shape were measured. Results indicated that individuals oriented attention to the cued target location following both non-predictive and predictive arrow cues, with shorter RT at the cued versus uncued locations. In contrast, while the non-predictive shape condition did not result in spatial orienting effects, volitional orienting was observed in the predictive shape condition. Ristic and Kingstone (2006; 2009) concluded that the use of a symbolic arrow cue in spatial-cueing paradigms engages both endogenous and exogenous orienting, and consequently reflects an interaction between exogenous and endogenous orienting rather than volitional orienting alone. As a result, more research is needed to clarify this issue, and clearly distinguish whether exogenous or endogenous processes are being measured in order to fully understand these processes in individuals with ASD

Next, many of the participants with ASD used in the previous studies were identified as having concurrent cerebellar (Courchesne et al., 1994; Harris et al., 1999, Townsend et al., 1999) or parietal lobe (Townsend et al., 1996) atypicalities. While there is evidence suggesting that neuroanatomical atypicalities are prevalent in individuals with ASD (Allen, Muller, Courchesne, 2004; Carper & Courchesne, 2000; Mundy, 2003; Townsend et al., 2001; Whitney, Kemper, Bauman, Rosene, & Blatt, 2008), it is unclear whether all individuals with ASD have cerebellar or parietal lobe atypicalities, or if they are specific to a subgroup of individuals. The extent to which the presence and severity of neuroanatomical atypicalities account for impairments in disengaging and shifting attention rapidly is also unclear. More research is needed to clarify this issue.

Furthermore, a number of studies examining visuospatial orienting in ASD measured reaction times to target stimuli to gauge the speed of attention shifts (Harris et al., 1999; Iarocci & Burack, 2004; Townsend et al., 1996). As a result, the impact of slowed motor preparation and execution, often observed in individuals ASD (Manjiviona & Prior, 1995; Mostofsky et al., 2006;

Théoret et al., 2005) cannot be discounted. Renner et al. (2006) examined the relationship between visuospatial orienting and motor skills in children with ASD and CA-and-IQ-matched TD children (Mean CA = 12.3 years). Visuospatial orienting was assessed using a variant of Posner's spatial-cueing task, and motor functioning was assessed using a series of tasks from the Motor Functioning Scale of the Luria-Nebraska Neuropsychological Battery-Children's Revision (LNNB-C; Golden, 1987). Results indicated that participants with poorer motor functioning were slower to shift and orient attention in the short cue-to-target delay condition, however showed intact attentional orienting in the long cue to target delay conditions.

In contrast, other researchers have reported that slowed attentional orienting in individuals with ASD does not result from slowed motor preparation and execution. In the response accuracy task implemented by Townsend (1999; see section 3.7.2), the target stimulus (i.e., the letter 'E' presented in different spatial orientations) was obscured by another symbol after 50ms. Participants were then given several seconds to use a joystick lever to indicate the direction of the target orientation (i.e., up, down, right, left), providing sufficient response time to compensate for slowed motor preparation and execution. This task thus separated the time to orient attention (i.e., the time between the onset of the cue and the target stimulus), from the time to process the target stimulus (i.e., the time between the presentation of the target and the onset of the mask) and the time to execute a motor response. Individuals with ASD were impaired in their ability to rapidly orient attention in the short cue-to-target-delay condition, despite having sufficient time to execute their motor response. As a result, Townsend et al. (1999) concluded that slowed orienting of attention in individuals with ASD was not a result of impaired motor functioning (Townsend et al., 1999). This is consistent with Courchesne et al. (1994), who reported that slowed orienting of attention in individuals with ASD was not caused by motor problems. It therefore remains unclear as to whether the orienting deficits reported in individuals with ASD result from attentional deficits or slowed motor planning and execution, or both. More research is needed to clarify this issue.

Finally, it is unclear whether the orienting deficits observed in studies of visuospatial orienting in ASD are confounded by difficulties disengaging the focus of attention. The majority of these studies required participants to fixate on a continuous central fixation point that was not removed prior to the presentation of the target stimulus (Harris et al., 1999; Renner et al., 2006; Townsend et al., 1996; 1999; Wainwright-Sharp & Bryson, 1993). Consequently, these tasks required the individual to disengage attention from the fixation point in order to move attention to the target stimulus. While impaired disengagement could be inferred from the abnormally large differences in RT's to validly and invalidly cued items for participants with ASD in the long cue-to-target delay condition (Harris et al., 1999; Renner et al., 2006; Townsend et al., 1996; 1999; Wainwright-Sharp & Bryson, 1993), the Posner spatial-cueing tasks employed do not provide strictly independent measures of the shift and disengagement components of attention (Landry & Bryson, 2004). Consequently, firm conclusions regarding whether orienting impairments were due to difficulties with disengagement, shifting, or both, cannot be made.

### *3.7.3 Disengagement of Attention*

The ability to disengage attention from the one stimulus in order to move attention to the another stimulus has received considerable research attention (Kawakubo et al., 2004; 2007; Landry & Bryson, 2004; Van der Geest et al., 2001; Zwaigenbaum et al., 2005). Many studies examining whether individuals with ASD are impaired in the shift and / or disengagement aspects of orienting attention to visual stimuli have used variants of the gap-overlap task (Saslow, 1967). This task allows for the shift and disengagement components of attention to be examined separately.

### *3.7.4 Gap-Overlap Task*

In the gap-overlap task, participants are seated in front of a computer screen and presented with two types of trials: shift trials and disengagement trials. On the shift trials (the gap condition),

a fixation point is presented until it is established that the participant is looking at the stimulus. The central (fixation) point is then removed, and a peripheral stimulus is presented until the participant makes an eye movement, or for a maximum time period. For disengagement trials (the overlap condition), the procedure is identical, however, the central fixation point remains for the entire trial. Eye movement latencies, or the time taken to initiate an eye movement from the central fixation point to the second stimulus, are recorded. The frequency of failures to disengage attention from the fixation point are also calculated. The critical manipulation in this task is whether the central fixation point remains (overlap / disengagement condition) or whether it is removed (gap / shift condition) prior to the presentation of the peripheral stimulus. It is predicted that saccadic latencies will be faster (e.g., approximately 150 ms) in the gap condition than in the overlap condition (e.g., approximately 220 ms) when attention is automatically disengaged by the removal of the fixation point (Saslow, 1967) and some preparatory steps in the initiation of the saccadic eye movements have likely taken place (Van der Geest et al., 2001). In contrast, attention is engaged at the fixation point at the onset of the target stimulus in the overlap condition. As engaged attention inhibits saccadic eye movements, it takes longer for the individual to move attention to the target stimulus in this condition. Differences in reaction times in the gap and overlap conditions are referred to as the 'gap effect' (Saslow, 1967).

### *3.7.5 Research using the Gap-Overlap Task in Individuals with ASD*

Several studies using the gap-overlap task have found evidence of impaired disengagement in individuals with ASD (Elsabbagh et al., 2009; Kawakubo et al., 2007; Landry & Bryson, 2004; Zwaigenbaum et al., 2005). The results of these studies show that participants with ASD take significantly longer to orient to the target stimulus when the fixation point remains on the screen as opposed to when it is removed prior to the onset of the target stimulus.

Landry and Bryson (2004) used the gap-overlap task to examine the disengagement and shift components of visual orienting in 15 children with ASD (mean CA = 5.6 years), 13 children



with Down Syndrome (Mean CA = 5.5 years) and 13 TD children (Mean CA = 3.6 years). Groups were matched on NVMA and verbal skills. Participants with ASD and Down Syndrome were additionally matched on CA. Results from the ‘shift’ trials showed that children with ASD and control subjects did not differ in their mean latency to shift attention between stimuli. Despite this, children with ASD demonstrated fewer ‘fast’ shifts relative to TD and DD children, indicating a deficit in their ability to shift attention rapidly between stimuli. A more significant deficit was observed on trials assessing disengagement. Specifically, while all children oriented more slowly to the peripheral stimulus on the disengage than shift trials, children with ASD took significantly longer to disengage attention from the fixation point relative to other groups of children. Children with ASD also demonstrated a significantly higher percentage of trials in which they failed to disengage from the fixation point for the entire 8-second trial. Landry and Bryson concluded that children with ASD were impaired in their ability to disengage attention, and demonstrated a more subtle impairment in their ability to rapidly shift attention between stimuli.

Using 150 ‘high-risk’ SIBA-A and 75 ‘low-risk’ infants with no first or second degree relatives with ASD, Zwaigenbaum et al. (2005) examined the behavioural markers of ASD in infancy. Groups were matched on CA, gender, and birth order. In this study, the Autism Observation Scale for Infants (AOSI; Bryson, McDermott et al., 2004) was administered. In the AOSI, infants were engaged in a semi-structured play format and specific target behaviours were assessed. Target behaviours included measures of visual tracking, eye gaze, and disengagement of attention. To further assess visual orienting and disengagement, infants were also presented with a gap-overlap task. As with previous tasks, the critical manipulation was whether the central fixation point remained or was removed prior to the onset of the target peripheral stimulus. Latencies to initiate an eye movement were recorded. All infants were assessed at two points: between 6 and 7 months of age and between 12 and 14 months of age. The mean CA of participants at the 6 to 7-month assessment period was 6.44 months and 12.50 months at the 12 to 14-month assessment

period. Infants were then evaluated at 36 months of age using DSM-IV criteria, the ADI-R (Lord, Rutter, & Le Couteur, 1994) and the ADOS (Lord et al., 2000) for possible ASD classification. Results indicated that infants later diagnosed with ASD could not be differentiated from other infants on their ability to disengage and shift attention at 6 to 7 months of age. By 12 months of age, however, a number of distinguishing behavioural markers were evident. In particular, infants who received an ASD diagnosis at 36 months demonstrated impaired visual tracking, longer latencies to disengage attention, and an impaired ability to rapidly shift attention across stimuli. Zwaigenbaum et al. (2005) further reported that all infants who showed a decrement in their ability to disengage attention between 6 and 12 months of age received a diagnosis of ASD. In contrast none of the infants who increased the speed with which they disengaged attention, or who performed similarly to the 6-month assessment, received a later ASD diagnosis. The authors concluded that impairments in disengaging and shifting attention can differentiate infants later diagnosed with ASD from other infants by 12 months of age.

In a more recent study, Kawakubo et al. (2007) examined the physiological aspects of shifting and disengaging attention using 16 adults with ASD (Mean CA = 29.0 years), 17 adults with an ID (Mean CA = 27.5 years) and 17 neurotypical adults (Mean CA = 28.5 years). Groups were matched on CA and gender, and the adults with ASD and those with an ID were matched on cognitive ability. In this study, participants were presented with a variation of the gap-overlap task during which their electrophysiological brain responses (i.e., event-related potentials; ERPs) elicited prior to the initiation of an eye movement towards the target stimulus were measured. Previous research using TD individuals (Csibra, Johnson, & Tucker, 1997; Gómez, Atienza, Gómez, & Vazquez, 1996), showed that positive ERP's (or presaccadic positivity) prior to an eye movement towards the target stimulus were longer in the overlap than gap condition, reflecting the additional neural resources and planning required to disengage attention (Balaban & Weinstein, 1985; Csibra et al., 1997; Gómez et al., 1996). The results of this study demonstrated that

individuals with ASD showed higher and longer periods of positive presaccadic activity than control subjects in overlap, but not the gap condition. Kawakubo et al. (2007) suggested that higher and longer positive spikes in pre-saccadic ERP's was indicative of impaired disengagement, and reflected the longer periods of neural activity and additional resources required by individuals with ASD to execute an eye movement away from the fixation point.

Other researchers (Kawakubo et al., 2004; Van der Geest et al., 2001) however, have failed to find evidence of impaired disengagement in individuals with ASD. In contrast to the previous studies, these researchers reported that the difference in saccadic latencies between the gap and overlap conditions for participants with ASD were smaller than for other groups of participants. The general interpretation of these findings is that individuals with ASD are not impaired in their ability to disengage and shift attention rapidly between visual stimuli, however, show a lower level of attentional engagement to the fixation point, relative to TD individuals.

Using the gap-overlap task, Van der Geest et al. (2001) reported that differences in saccadic latencies between the gap and overlap conditions for children with ASD (Mean CA = 10.9 years) were smaller than for CA-and-IQ-matched TD children (Mean CA = 10.3 years). The authors proposed that children with ASD were less engaged at the central fixation point in the overlap condition and, as a result, showed faster saccadic responses towards the target stimulus. In a similar study using adults with ASD (Mean CA = 30.5 years) and TD adults (Mean CA = 24.9 years), Kawakubo et al. (2004) examined visuospatial orienting using a variation of the gap-overlap task in which express saccades were measured in addition to saccadic latencies in the gap and overlap conditions. Express saccades are eye movements with short reaction times (e.g., approximately 80ms; Fischer, 1987; Fischer & Breitmeyer, 1987; Fischer & Ramsperger, 1984; 1986), and are indicative of disengaged attention. Express saccades are inhibited when attention is actively engaged, and would therefore not be expected to occur in the overlap condition when attention is engaged at the fixation stimulus (Fischer & Weber, 1993). While group differences in

saccadic reaction times for the gap and overlap conditions were not observed, results showed that participants with ASD demonstrated more express saccades in the overlap condition than TD participants. Furthermore, while the groups did not differ on the frequency of express saccades made in the gap condition, TD participants demonstrated a higher number of express saccades in the gap than overlap conditions. Kawakubo et al. (2004) concluded that the increased frequency of express saccades observed in participants with ASD in the overlap condition, was indicative of decreased attentional engagement.

#### *3.7.5.1 Summary of Research using the Gap-Overlap Task in ASD*

A number of studies have shown that individuals with ASD are significantly slower to respond to a target stimulus when required to disengage and move attention from a central fixation point, relative to TD individuals. Impaired disengagement in individuals with ASD was reported in studies using behavioural (Elsabbagh et al., 2009; Landry & Bryson, 2004; Zwaigenbaum et al., 2005) and physiological (Kawakubo et al., 2007) assessments, and in individuals with ASD across different ages and developmental levels. Impaired disengagement in infancy was reported to be a significant predictor of an ASD diagnosis later in life (Zwaigenbaum et al., 2005), and does not appear to be affected by cognitive ability (Kawakubo et al., 2007; Landry & Bryson, 2004). Impaired disengagement was reported in children with ASD with average or above average intelligence (Landry & Bryson, 2004) and in adults with ASD relative to IQ-matched ID participants (Kawakubo et al., 2007). The notion of impaired disengagement in ASD is consistent with the abnormally large cue-validity-effects reported in studies using variants of Posner's visual cueing task with children (Harris et al., 1999; Renner et al., 2006) and adults (Townsend et al., 1999; Wainwright-Sharp & Bryson, 1993) with ASD.

Other studies, however, failed to find evidence of impaired disengagement in individuals with ASD (Kawakubo et al., 2004; Van der Geest et al., 2001). In these studies, participants with ASD showed smaller gap effects (Van der Geest et al., 2001) and made more express saccades (Kawakubo et al., 2004) than other groups of participants. These findings were interpreted as

evidence of a lower level of attentional engagement in participants with ASD relative to control subjects.

It is possible that methodological variations in task requirements and developmental variables may account for the different findings reported in these studies. First, in all of the studies reporting that individuals with ASD were impaired in disengaging attention, dynamic stimuli in the form of cascading coloured shapes that filled the screen (Landry & Bryson, 2004), coloured shapes (Zwaigenbaum et al., 2005) or illustrations of animals and common objects (Kawakubo et al., 2007) were utilized. However, in the two studies reporting that individuals with ASD were unimpaired in their ability to disengage attention from a central fixation point (Kawakubo et al., 2004; Van der Geest et al., 2001), simple white shapes were utilized for both the fixation point and the target stimulus. It is possible that dynamic, colourful stimuli are more engaging than simple white shapes for individuals with ASD, resulting in difficulties disengaging attention from these stimuli for these participants. Thus, an impaired ability to disengage attention may not be observed across all types of stimuli for individuals with ASD, and may only be exhibited when viewing more salient, engaging stimuli.

Second, the majority of studies using the gap-overlap paradigm found evidence of impaired disengagement in young children (Landry & Bryson, 2004) and infants (Elsabbagh et al., 2009; Zwaigenbaum et al., 2005) with ASD. It is possible that the older participants employed by Van der Geest et al. (2001) and Kawakubo et al. (2004) may account for group differences. Problems disengaging attention in ASD may thus be more prevalent earlier in life and improve with age, however, at a point in development that may be too late to avoid disrupting early social and cognitive development (Bowler, 2007). In support of this notion, evidence of age-related improvements in disengagement as evidenced by the systematic decrease in latencies to disengage attention throughout childhood in TD children and those with ASD has been documented (Luna et al., 2007).

Inconsistent with this notion, however, is the finding of impaired disengagement in adults with ASD by Kawakubo et al. (2007). This may be attributed to critical methodological differences from the traditional gap-overlap paradigm in their study. Specifically, the task employed by Kawakubo et al. (2007) was more complex than that of a traditional gap-overlap paradigm, and required the participants' to discriminate between the stimuli rather than make a simple detection. As a result, it is possible that while age-related improvements in the ability to disengage attention may be observed in individuals with ASD on tasks with lower cognitive demands, impaired disengagement may persist into adulthood on tasks with more complex cognitive demands, or when required to disengage attention from more complex stimuli.

#### *3.7.5.2 Limitations of Research using the Gap-Overlap Task in ASD*

The majority of studies assessing disengagement in individuals with ASD were limited by employing measures of overt attention. Atypical saccades and other eye movements have been implicated in ASD in some studies (Luna et al., 2007; Takarae, Minshew, Luna, Krisky, & Sweeney, 2004; Takarae, Minshew, Luna, & Sweeney, 2004). However, other researchers have reported that basic oculomotor functions are intact in individuals with ASD (Goldberg, Landa, Lasker, Cooper, & Zee, 2000; Minshew et al., 1999; Nowinski, Minshew, Luna, Takarae, & Sweeney, 2005). As a result, the extent to which impaired eye movements impact on disengaging and shifting attention, particularly when required to make overt eye movements towards the target stimulus, is unclear. Firm conclusions regarding whether observed deficits are due to impairments in oculomotor functions, disengagement, or both, cannot be made. This issue requires further investigation.

Similarly, the potential impact of motor skills on participants' eye movements were not controlled for in any of these studies (Elsabbagh et al., 2009; Kawakubo et al., 2007; Landry & Bryson, 2004; Van der Geest et al., 2001; Zwaigenbaum et al., 2005). While a relationship between motor skills and visual orienting was established in one study (Renner et al., 2006), other

researchers have reported that orienting skills are unaffected by motor preparation and execution (Courchesne et al., 1994; Townsend et al., 1999). This issue remains unclear. Finally, the use of different methodologies, age groups, levels of cognitive ability and matching procedures in these studies make comparisons across studies difficult.

### *3.7.6 Additional Limitations of Studies Examining Visuospatial Orienting in ASD*

There are several additional limitations that pertain to both Posner spatial-cueing and gap-overlap paradigms. First, all of the aforementioned studies utilized variants of a computerised spatial-cueing task. The stimuli utilized were neither meaningful nor naturally occurring, and failed to reflect the continuous stream of visual and auditory stimuli experienced in natural settings throughout which attention must be constantly disengaged, shifted and refocused. Consequently, the extent to which these findings reflect spontaneous orienting behaviour in the naturalistic setting is questionable.

An additional limitation of the previous studies pertains to the group matching procedures employed. A number of researchers failed to match groups on language or cognitive ability (Elsabbagh et al., 2009; Harris et al., 1999; Townsend et al., 1999; Wainwright-Sharp & Bryson, 1993; Zwaigenbaum et al., 2005), and any association between IQ and orienting attention was not examined in control groups. While a number of researchers have established a relationship between cognitive ability and speed of orienting (Ozonoff et al., 1991), other researchers have reported that the ability to disengage and shift attention is independent of cognitive functioning (Courchesne et al., 1994; Harris et al., 1999; Iarocci & Burack, 2004; Kawakubo et al., 2007; Landry & Bryson, 2004; Renner et al., 2006; Townsend et al., 1999). Thus, the impact of intellectual functioning on the speed and accuracy with which individuals shift attention remains unclear and warrants further consideration.

### 3.8 Unresolved Issues Pertaining to Shifting and Disengagement in ASD

The research presented in this chapter supports the notion that individuals with ASD are impaired in their ability to disengage and shift attention. Participants with ASD were slower to disengage attention from a central fixation point (Elsabbagh et al., 2009; Harris et al., 1999; Kawakubo et al., 2007; Landry & Bryson, 2004; Renner et al., 2006; Townsend et al., 1996; 1999; Wainwright-Sharp & Bryson, 1993; Zwaigenbaum et al., 2005), and redirect attention when required to interpret a cue or cue-target relationship (Harris et al., 1999; Renner et al., 2006; Townsend et al., 1996; 1999; Wainwright-Sharp & Bryson, 1993). Several researchers additionally proposed that slowed shifting of attention in individuals with ASD was related to an impaired ability to prepare and execute a shift of visual attention toward the target stimulus (Elsabbagh et al., 1999; Landry et al., 2009). However, the exact nature of the deficit in disengaging and shifting attention in individuals with ASD, and whether the observed impairments were due to an impaired ability to shift or disengage attention, or both, remains unclear.

First, there is evidence to suggest that the orienting impairments observed in individuals with ASD may be strongly influenced by the nature of the stimuli to be processed. Consistent with this notion, researchers have demonstrated that participants with ASD may only show an impaired ability to disengage and shift attention from stimuli on which their attention has been focused for a period of time (Pascualvaca et al., 1998), or when required to ‘zoom out’ and shift attention from a narrow to a broad focus, once attention has been ‘set’ narrowly. (Mann & Walker, 2003; Rinehart et al., 2001). A large body of research also suggests that individuals with ASD show the greatest orienting impairment for social stimuli. Researchers have demonstrated that individuals with ASD shift attention to and between non-social stimuli as quickly and frequently as other groups of individuals (Leekam & Moore, 2001; Newell, Bahrack, Vaillant-Molina, Shuman, & Castellanos, 2007; Swettenham et al., 1998), however, show an impaired ability to shift attention to social stimuli (Dawson et al., 1998; 2004; Klin, Jones, Schultz, Volkmar, & Cohen, 2002; Maestro et al.,



2005; Osterling et al., 2002; Riby & Hancock, 2009b; Speer, Cook, McMahon, & Clark, 2007; Swettenham et al., 1998). Visual fixation times for social and non-social stimuli also vary markedly, with longer fixations to non-social stimuli and shorter fixations to social stimuli observed in individuals with ASD relative to control subjects (Newell et al., 2007; Riby & Hancock, 2009a; Swettenham et al., 1998). The impact of stimulus-characteristics were further highlighted by the suggestion that individuals with ASD showed the greatest impairment disengaging attention from dynamic, engaging stimuli (Kawakubo et al., 2007; Landry & Bryson, 2004; Zwaigenbaum et al., 2005). When considered with the finding of impaired attentional engagement in ASD (Kawakubo et al., 2004; Van der Geest et al., 2001), these results reflect a pattern of orienting that is appears to be intact under some conditions and impaired in others.

Second, the role of an impaired ability to disengage and shift attention in the development of ASD-related symptomatology is unclear. Difficulties disengaging and shifting attention occur in other developmental disorders with markedly different social and cognitive profiles from ASD (Brown et al., 2003; Cornish, Scerif, & Karmiloff-Smith, 2007; Scerif, Cornish, Wilding, Driver, & Karmiloff-Smith, 2004 ). For example, individuals with the neurodevelopmental disorder Williams Syndrome (WS) are impaired in disengaging and shifting attention (Brown et al., 2003; Cornish et al., 2007; Scerif et al., 2004). However, in contrast to ASD, WS is characterized by hyper-sociality (Doyle, Bellugi, Korenberg, & Graham, 2004; Frigerio et al., 2006; Jones et al., 2000), and an inability to inhibit social responses (Porter, Coltheart, & Langdon, 2007). A series of research studies conducted by Riby and Hancock (2008; 2009a; 2009b) reported that while individuals with ASD preferentially attend to non-social stimuli, individuals with WS preferentially attend to social stimuli. Thus, it appears that impairments in shifting and disengaging attention alone cannot account for the impairments characteristic of either WS or ASD, and need to be considered within the context of other factors, such as the nature of the stimuli that are preferentially attended to. For individuals with ASD, overly focused attention to non-social stimuli

and difficulties shifting and disengaging attention from salient sources of non-social stimuli may confound their reduced tendency to orient to social stimuli, resulting in an impoverished social experience at a critical point in development. These findings thus highlight the role of visual preferences to socially relevant information in the socio-cognitive profiles of these disorders, and suggest that a decreased tendency to orient attention to certain types of stimuli may be confounded by difficulties disengaging and shifting attention from other, more salient sources of stimuli.

### 3.9 Chapter Summary and Conclusions

The current chapter summarized the orienting attention literature for individuals with ASD. The results of the research revealed that children, adolescents and adults with ASD oriented attention between visual stimuli more slowly, and were impaired in disengaging attention from a salient stimulus relative to other groups of participants. In contrast, other researchers reported that individuals with ASD showed lower levels of attentional engagement than control subjects. Orienting deficits were not attributed to cognitive impairment or impaired motor functioning in a number of studies. Impairments in disengaging and shifting attention are evident in the first year of life, and precede the emergence of other social and cognitive impairments associated with ASD. As a result, a number of researchers have proposed that these deficits may underlie the symptomatology associated with ASD.

Evidence suggests, however, that the severity of the orienting impairment observed in ASD may be influenced by the nature of the stimuli to be processed. An impaired ability to disengage and shift attention between stimuli is not specific to ASD, and is observed in individuals with markedly different social and cognitive profiles. As a result, the extent to which these impairments account for the specific social, behavioural and cognitive impairments associated with ASD is questionable. It is possible that problems disengaging and shifting attention confound other deficits such as impaired orienting to social stimuli. The role of social orienting in the social impairments of individuals with ASD should therefore be considered.

## CHAPTER 4: SOCIAL ORIENTING

### 4.1 Chapter Overview

The current chapter provides an overview and critical analysis of the research examining social orienting in individuals with ASD. In particular, research examining social and non-social orienting within the same population of individuals with ASD is reviewed to examine whether social orienting deficits are distinct from general underlying attentional deficits in these individuals. For each section, the relevant research studies are outlined. The findings from the research studies are then discussed, and the methodological limitations pertaining to the studies are reviewed.

### 4.2 Social Orienting

Social orienting refers to the ability to spontaneously direct attention to social stimuli in the environment (Dawson et al., 1998; 2004). It is considered a critical component of social information processing and development (Mundy & Neal, 2001; Wainwright & Bryson, 2002). The ability to orient to human faces has been a particular focus of many studies examining social orienting. Due to its social and evolutionary importance, the human face is among the most salient stimuli in the environment. Orienting to the facial region is an early developing skill reflected by the innate preference of TD infants to orient to human faces (Farroni et al., 2005; Johnson & Farroni, 2003; Macci Cassia, Turati, & Simion, 2004; Maestro et al., 2005). It has been proposed that faces are processed in a different manner to other environmental stimuli as they may capture attention automatically or exogenously, are detected faster than non-social alternatives (Lewis & Edmonds, 2005; Theeuwes & van der Stigchel, 2006), and are discriminated from other environmental stimuli pre-attentively (Theeuwes & van der Stigchel, 2006). Orienting to the facial region early in life reportedly influences the development of neural face processing mechanisms

(Johnson & Farroni, 2003) and subsequent social and communicative development (Elsabbagh et al., 2009).

#### 4.3 Typical Development of Social Orienting

TD infants show a natural proclivity to attend to salient social stimuli from birth, preferentially attending to biological motion (Klin, Lin, Gorrindo, Ramsay, & Jones, 2009), and human faces and face-like configurations (Farroni et al., 2005; Johnson & Farroni, 2003; Macchi Cassia et al., 2004; Maestro et al., 2005) within the first few days of life. Studies of newborn infants have also consistently shown that they preferentially orient their gaze and look for longer durations at upright faces or face-like configurations, than equally complex non-face-like stimuli (Macchi Cassia et al., 2004; Mondloch, Le Grand, & Maurer, 2003). At this age, infants also spend most of their time in dyadic face-to-face interactions, and rarely look away towards peripheral non-social stimuli (Leekam, Lopez et al., 2000). Additional research has shown that TD newborns show a capacity to process and form representations of faces (Turati, Macchi Cassia, Simion, & Leo, 2006). They are able to recognize their mother's face when paired with an unfamiliar face (Bartrip, Morton, & de Schonen, 2001; Bushnell, 2001), and preferentially attend to faces with open eyes (Batki, Baron-Cohen, Wheelwright, Connellan, & Ahluwalia, 2000), and those depicting a direct, rather than averted, gaze (Farroni, Csibra, Simion, & Johnson, 2002). Throughout this period, newborns' face processing is reliant on both internal and external features of the face, however, the external contour of the face provides more salient perceptual cues for processing (Pascalis, de Schonen, Morton, Deruelle, & Fabre-Grenet, 1995; Turati et al., 2006).

By 2 months of age infants' fixations to the external contour of the face decreases, and the extent to which they fixate on the more socially informative parts of the face, namely the eyes and mouth, increases. At this age, infants also show a preference for interactive as opposed to still faces, as demonstrated by longer fixations to dynamic facial stimuli (Pascalis et al., 1995). By approximately 3 months of age, infants show evidence of the development of face categorization

(Pascalis & Kelly, 2009). In particular, they show a preference for faces corresponding with their own ethnicity (Bar-Haim, Ziv, Lamy, & Hodes, 2006; Kelly et al., 2007) and the gender of their primary caregiver (Quinn, Yahr, Kuhn, Slater, & Pascalis, 2002). Between 3 and 10 months of age, infants also undergo a change in their capacity to process faces in a configural manner. They no longer process the internal and external features of the face separately, and begin to process the relationship between them (Cashon & Cohen, 2003).

By 4 months of age infants demonstrate an emerging ability to shift attention between social and non-social stimuli, and become increasingly sensitive to eye gaze. They are able to shift their attention from an adult's face, toward a third object in an adult's hand, and then back to the adult's face (Amano, Kezuka, & Yamamoto, 2004). By 5 months of age, infants show an awareness of small deviations in eye gaze within the context of social interactions (Symons, Hains, & Muir, 1998). They are able to use eye gaze to locate an object (Corkum & Moore, 1998; D'Entremont, Hains, & Muir, 1997), and show an ability to match the direction of their mother's head turn to locate a target in their immediate visual field (Morales, Mundy, & Rojas, 1998). They also show an ability to discriminate between expressions of emotions such as smiling and fearful expressions (Bornstein & Arterberry, 2003). Between approximately 5 and 7 months of age, infants begin orienting to their name (Dawson & Bernier, 2007). The strong attentional preference for social stimuli continues throughout childhood and adulthood, with TD individuals showing a strong attentional preference for social stimuli across the lifespan (Cerf, Harel, Einhäuser, & Koch, 2008; Fletcher-Watson, Findlay, Leekam, & Benson, 2008; Theeuwes & van der Stigchel, 2006).

In summary, from the first few weeks of postnatal life, salient social stimuli such as human faces and biological motion capture the visual attention of TD infants, and continue to hold more salience than other aspects of the environment throughout the lifespan (Cerf et al., 2008; Theeuwes & van der Stigchel, 2006). While it is unclear whether this bias results from the presence of a biologically determined mechanism (Farah, Rabinowitz, Quinn, & Liu, 2000), if it is acquired through the experience of a social-rich environment (Gauthier & Tarr, 2002), or if it results from a

general visual preference (Macci Cassia et al., 2004; Simion, Cassia, Turati, & Valenza, 2001), it is clear that attention to salient social stimuli holds great developmental importance. It has been proposed that early visual input from social stimuli is critical for the development of expertise and specialization in face processing (Geldart, Mondloch, Maurer, de Schonen, & Brent, 2002), which is considered a precursor to the development of more complex social interactions and cognition (Dawson, Webb, & McPartland, 2005). The importance of visual input from social stimuli is supported by research demonstrating the presence of social impairments and behaviours that are characteristic of AD in congenitally blind individuals (Hobson & Bishop, 2003). Similarly, infants deprived of early visual experiences due to bilateral cataracts experience long-term difficulties with facial recognition and the holistic processing of faces despite years of compensatory treatment and visual experiences following the removal of the cataracts (Geldart et al., 2002; LeGrand, Mondloch, Maurer, & Brent, 2004).

#### 4.4 Social Motivation Hypothesis of ASD

A number of theorists have proposed that ASD symptomatology stems from an impairment in the lower-level cognitive mechanisms responsible for preferential attention to social stimuli (Dawson, Carver et al., 2002; Grelotti, Gauthier, & Schultz, 2002; Klin, Jones, Schultz, & Volkmar, 2003; Mundy & Neal, 2001; Schultz, 2005). A failure to actively attend to social stimuli, seek out social experiences, and extract meaning from social interactions in infancy circumvents the normal development of face processing specialization, and deprives the neural systems that subserve face processing of critical input (Dawson, Webb, Wijsman et al., 2005; Mundy & Neal, 2001). Over time, reduced social orienting coupled with the related neurological disturbances, results in inferior social experiences for the developing infant. Fewer and poorer quality social experiences and reduced attention to social stimuli deprive the child of the necessary foundations for the development of more complex social behaviours and understanding.

According to proponents of the social motivation hypothesis, the lack of preferential attention to social stimuli in ASD may stem from a primary impairment in social motivation (Dawson, Carver et al., 2002; Dawson, Webb, Wijsman et al., 2005; Grelotti et al., 2002; Mundy & Neal, 2001), and an intrinsic failure to perceive social stimuli (e.g., faces) as salient (Schultz, 2005). The lack of salience attributed to social stimuli reduces the extent to which faces, voices, gestures, biological motion, affect and other socially-relevant stimuli capture and sustain the attention of individuals with ASD, and impedes the development of expertise in face perception, the ability to interpret social cues, JA, gaze monitoring, emotional understanding, and social cognition (Dawson, Webb, & McPartland, 2005; Dawson, Webb, Wijsman et al., 2005; Grelotti et al., 2002; Klin et al., 2002; Schultz, 2005).

Dawson, Carver et al. (2002) proposed that the primary impairment in social motivation in ASD stems from the failure of these individuals to assign reward value to salient social stimuli (Dawson, Osterling, Rinaldi, Carver, & McPartland, 2001; Mundy & Neal, 2001). They hypothesised that dopaminergic reward pathways fail to activate in response to typically rewarding social behaviours (e.g., eye-contact and smiles), impairing the formation of reward associations for social stimuli or “emotional learning” (Schultz, 2005), and the tagging of emotionally relevant stimuli (Dawson, Carver et al., 2002; Dawson, Webb, & McPartland, 2005). The predicted reward value of a stimulus motivates and directs the attention of TD infants from approximately 6 months of age (Dawson, Webb, & McPartland, 2005).

Several lines of evidence support the notion of a primary impairment in social motivation for infants and children with ASD. First, recent research by Klin and colleagues (2010) indicates that infants who later develop ASD are born with an adaptive reflex to orient to faces and in particular, the eye region of the face. However, as the reflex to orient to others interacts with experience, fixations to the eye region of the face reportedly decrease in infants later diagnosed with an ASD, while they increase or remain constant for TD infants. Thus, the formation of reward value for salient social stimuli (e.g., the eye region of the face), which would serve to increase or

maintain attention to salient social stimuli, appears to be impaired for infants later diagnosed with ASD. Second, deficits in basic social orienting behaviours such as poor eye-contact, a failure to orient to one's name and a lack of interest in other people are often present by the end of the first year of life in infants with ASD (Clifford et al., 2007; Maestro et al., 2005; Osterling et al., 2002; Watson et al., 2007). These behaviours are often the first recognisable signs of ASD, and precede the well documented deficits in JA, imitation, social behaviour, and cognition (Dawson, Carver et al., 2002; Dawson et al., 2004). Core diagnostic criteria for ASD also require that the child exhibit behaviours indicative of a reduced motivation for social stimuli and interactions (DSM-IV-TR; APA, 2000). Third, deficits orienting to social stimuli are observed in children, adolescents, and adults with ASD (Klin et al., 2002; Newell et al., 2007; Riby & Hancock, 2008; 2009a; 2009b; Speer et al., 2007; Swettenham et al., 1998), indicating that social orienting impairments are sustained over time. Fourth, neural systems that mediate attention to, and comprehension of, salient social stimuli such as faces are reportedly atypical in individuals with ASD (Kleinmans et al., 2008; McPartland, Dawson, Webb, Panagiotides, & Carver, 2004; Nacewicz et al., 2006; Schumann et al., 2004; Webb, Dawson, Bernier, & Panagiotides, 2006). These atypicalities are not observed for processing non-social stimuli (McPartland et al., 2004).

As a result of the observed impairment in orienting attention to social stimuli in ASD, a number of researchers have examined whether or not individuals with ASD are impaired in orienting attention to all stimuli, or show a specific impairment in orienting attention to social stimuli (Fletcher-Watson, Findlay, Leekam, & Benson, 2009; Klin et al., 2002; Riby & Hancock, 2008; 2009a; 2009b; Speer et al., 2007; Swettenham et al., 1998; Van der Geest, Kemner, Verbaten, & Van Engeland, 2002). While mixed findings have been reported, support for the notion of impaired social orienting in ASD has been obtained from studies examining the early social orienting of infants later diagnosed with ASD; including the retrospective analysis of infants later diagnosed with ASD (Baranek, 1999; Clifford et al., 2007; Maestro et al., 2005; Osterling & Dawson, 1994; Osterling et al., 2002; Watson et al., 2007; Werner et al., 2000; 2005), prospective



studies of high risk infant siblings of children with ASD (Ibanez et al., 2008; Zwaigenbaum et al., 2005), and studies of responsivity to auditory social stimuli (Dawson et al., 1998; 2004). Further support for the notion of impaired social orienting in ASD has been derived from research examining the spontaneous distribution of attention across stimuli (Klin et al., 2002; Riby & Hancock, 2008; 2009a; 2009b; Speer et al., 2007), and research examining attention shifts in response to social and non-social cues (Senju, Tojo, Dairoku, & Hasegawa, 2004; Vlamings, Stauder, van Son, & Mottron, 2005) in children, adolescents and adults with ASD. These areas of research will be reviewed in Sections 4.5, 4.6 and 4.7.

#### 4.5 Early Social Orienting in Infants Later Diagnosed with ASD

It is uncommon for ASD's to be conclusively diagnosed prior to 2 years of age (Ibanez et al., 2008). As a result, direct observations of infants with ASD are lacking. Several researchers have attempted to overcome this issue by examining the developmental course of ASD in its earliest stages using retrospective video analysis (Baranek, 1999; Clifford et al., 2007; Maestro et al., 2005; Osterling & Dawson, 1994; Osterling et al., 2002; Werner et al., 2000), retrospective parent report (Watson et al., 2007; Werner et al., 2005) and prospective studies of high-risk infant siblings of children with ASD (SIBS-A; Ibanez et al., 2008; Zwaigenbaum et al., 2005).

##### *4.5.1 Research Studies Using Retrospective Video Analysis*

Retrospective video analysis is an ecologically valid tool that allows for the direct observation of infants later diagnosed with ASD in naturalistic settings. It permits the longitudinal observation and analysis of key behaviours, and provides objective data pertaining to the early behavioural characteristics of ASD (Clifford et al., 2007). Retrospective video analysis of home movies taken during the child's first year of life has shown that measures of social orienting can discriminate children later diagnosed with ASD from other groups of children. Using interval scoring procedures, Osterling and Dawson (1994) coded home videotapes of first year birthday parties for 11 infants later diagnosed with ASD and 11 TD infants. Key social, communicative,

affective and JA behaviours were rated as being absent or present in each minute of video footage. Results indicated that individuals who later received a diagnosis of ASD responded to their name and looked at the face of another person significantly less frequently than TD infants. The frequency with which a child looked at the face of another person was the single best predictor of an ASD diagnosis later in life. In a subsequent study using the same infants at 8 to 10 months of age, and an additional four infants in each group, Werner et al. (2000) found that social attention behaviours could distinguish infants later diagnosed with ASD from TD infants as early as 8 months of age. Specifically, infants later diagnosed with ASD exhibited less eye-contact with another person while smiling, and failed to respond to their name significantly more frequently than TD infants. Similar results were obtained by Maestro et al. (2002; 2005), who examined social and non-social orienting in 15 infants later diagnosed with ASD and 13 TD infants at two time intervals: 0 to 6 months (T1) and 7 to 12 months (T2). Results indicated that infants later diagnosed with ASD looked at, smiled, vocalized, and oriented attention towards people significantly less frequently than TD control subjects at T1, however group differences for the same behaviours were not observed at T2. Additionally, while both groups of participants showed an increase in attention to non-social stimuli between T1 and T2, the increase in attention to non-social stimuli was significantly greater for participants with ASD. Taken together, these findings provide evidence of atypical developmental trajectories in attention to both social and non-social stimuli in the first year of life for infants later diagnosed with ASD (Maestro et al., 2005).

Other studies have extended the previous findings by including additional groups of infants later diagnosed with a developmental delay (DD; Baranek, 1999; Clifford et al., 2007; Osterling et al., 2002). Using video footage of 11 children with ASD, 10 DD children and 11 TD children aged 9 to 12 months of age, Baranek (1999) reported that infants later diagnosed with ASD oriented to their name significantly less frequently than TD and DD infants. Infants later diagnosed with ASD were also impaired in orienting to non-social stimuli, as evidenced by less frequent orienting to all visual stimuli than other groups of infants. Infants with ASD did not differ from other infants in the

rate with which they looked at people in this study. Likewise, using video footage obtained from first birthday parties, Osterling et al. (2002) reported that infants later diagnosed with ASD oriented to their name, looked at people, and looked at objects held by others significantly less frequently than TD infants. Orienting to name was the best predictor of group membership followed by looking at objects held by other people and looking at people respectively. Results further showed that infants who received a later diagnosis of ASD with a co-morbid diagnosis of ID oriented to their name and looked at other people significantly less frequently than non-autistic infants who were later diagnosed with an ID. Finally, in a more recent study using 15 infants later diagnosed with ASD, 15 infants later diagnosed with a DD and 15 TD infants, Clifford et al. (2007) used home movies taken between 12 to 24 months to analyse the frequency and quality of basic social behaviours observed during free-play. Results indicated that infants with ASD showed a lower rate and quality of peer interest, response to name, and eye-contact. Clifford et al. (2007) concluded that between 12 and 24 months of age, basic dyadic social behaviours such as eye-contact and affect, differentiated infants later diagnosed with ASD from those later diagnosed with a DD to a greater extent than commonly reported triadic JA behaviours.

#### *4.5.2 Research Studies Using Retrospective Parent Report*

Other retrospective studies have utilized parental report to assess the early behaviour of children later diagnosed with ASD. Werner et al. (2005) examined the developmental profiles of 72 children with ASD, 34 non-autistic DD children, and 39 TD children. Groups were matched on MA. Participants with ASD and those with a DD were further matched on CA. In this study, the Early Development Interview (Werner et al., 2005) was administered to parents, during which they were required to answer in-depth questions pertaining to their child's behaviour from birth through to 2 years of age across several domains. To improve parent recall, the longitudinal follow-up interval evaluation (LIFE; Keller et al., 1987) protocol was adopted. Results indicated that by 3 to 6 months of age, infants with ASD could be differentiated from TD infants on the basis of abnormalities in social and regulatory behaviours. Specific behaviours shown to be impaired in

infants with ASD included an increased attention span for objects and a lack of smiling. By 12 to 15 months of age, infants with ASD could be further differentiated from DD infants on the basis of social behaviours, such as reduced eye-contact, social interaction, and orienting to name, and a failure to use JA skills to share attention with others.

In a similar study, Watson et al. (2007) used retrospective parental report to examine the early behavioural markers of ASD in 38 children with ASD, 15 children with a DD and 40 TD children matched on CA. Groups had mean CA's of 46.1, 45.1 and 39.3 months respectively. In this study, the First Year Inventory (FYI; Reznick, Baranek, Reavis, Watson, & Crais, 2007) was administered via parent report. Results indicated that parents of children with ASD reported significantly higher levels of impairment in the social orienting, receptive communication, social affective engagement and reactivity clusters at 12 months of age, relative to comparison groups. In particular, infants later diagnosed with ASD oriented to their name and turned to voices less frequently, and showed less interest in other infants and adults than both TD and DD infants.

#### *4.5.3 Research Studies Using Prospective Studies of High Risk Infant Siblings of Children with ASD*

In addition to examining retrospective video footage of children later diagnosed with ASD, researchers have examined groups of infant siblings of children with ASD for evidence of impaired social orienting. As stated in Chapter 1, Section 1.5, SIBS-A are at increased risk of developing an ASD, with a 6 to 15% concordance rate (Dawson, 2008). Thus, a number of studies have examined these infants longitudinally to identify the early behavioural markers of ASD.

Zwaigenbaum et al. (2005), assessed SIBS-A and infant siblings of TD children (SIBS-TD) at 6 and 12 months of age using the Autism Observation Scale for Infants (AOSI; Bryson, McDermott et al., 2004) and the gap-overlap task (refer to Chapter 3, Section 3.7.5 for a full description of this study). The results indicated that while a small number of infants later diagnosed with ASD showed fewer social initiations and less responsiveness to attention bids at 6 months of age, they could not, as a group, be reliably differentiated from other SIBS-A and infant siblings of

TD children. However, at 12 months of age, SIBS-A who later received a diagnosis of ASD showed an impaired ability to orient attention to social stimuli in their environment as evidenced by atypical eye-contact, impaired orienting to name, and reduced social interest. These infants also showed longer durations of gaze fixations to non-social stimuli and spent significantly less time engaged in the visual exploration of their environment.

#### *4.5.4 Summary of Research Examining Infants Later Diagnosed with ASD*

The results of these studies indicate that impaired social orienting is an early behavioural marker that can reliably distinguish infants later diagnosed with ASD from TD and DD infants within the first year of life. Infants later diagnosed with ASD established eye-contact (Clifford et al., 2007; Osterling & Dawson, 1994; Werner et al., 2000; Zwaigenbaum et al., 2005), looked at people's faces (Clifford et al., 2007; Osterling et al., 2002; Zwaigenbaum et al., 2005) and oriented to their name (Baranek, 1999; Clifford et al., 2007; Osterling & Dawson, 1994; Osterling et al., 2002; Werner et al., 2000; Zwaigenbaum et al., 2005) significantly less frequently than TD and DD infants. The most consistent and significant finding to emerge from these studies is that infants later diagnosed with ASD were significantly less likely than non-autistic infants to respond to their name. Impaired social orienting in infants with an ASD appears to be independent of cognitive functioning (Baranek, 1999; Clifford et al., 2007; Osterling et al., 2002).

However, social orienting deficits in the first year of life were not observed for all infants later diagnosed with ASD. Using retrospective video analysis, Werner et al. (2000) and Osterling et al. (2002) reported that social orienting behaviours were unimpaired in infants who were classified by their parents as late-onset ASD (i.e., infants with apparently normal development followed by the acquisition of ASD symptomatology between 14 and 24 months of age; Landa et al., 2007). Similarly Osterling et al. (2002) reported that infants with late-onset ASD oriented to their name, attended to objects held by people, and looked at people significantly more frequently at 12 months of age than infants classified as early onset ASD. They further reported that social orienting behaviours in infancy could reliably differentiate 90% of infants with early versus late onset ASD.

These findings are consistent with other studies documenting different developmental pathways for infants with an early versus late onset of ASD-related symptomatology (Werner & Dawson, 2005). Thus, while social orienting behaviours may reliably differentiate infants with early-onset ASD from TD and DD infants by the end of the first year of life, it may not be possible to identify infants exhibiting a later onset of ASD-related symptomatology on the basis of these behaviours at this age.

The age at which infants with ASD can be differentiated from other infants on the basis of social orienting behaviour remains unclear. Maestro et al. (2005) and Werner et al. (2005) reported that while infants with ASD could be differentiated from TD infants on the basis of increased attention to non-social stimuli and decreased attention to people by 6 months of age (Maestro et al., 2005; Werner et al., 2005), social orienting behaviour could not reliably differentiate infants with a later diagnosis of ASD from those with a DD until approximately 12 months of age (Baranek, 1999; Osterling et al., 2002). Similarly, Zwaigenbaum et al. (2005) reported that impairments in social orienting and disengagement could not differentiate infants later diagnosed with ASD from TD infants until approximately 12 months of age. While this issue requires further investigation, it is possible that developmental differences in social orienting in infants later diagnosed with ASD become more pronounced between 6 and 12 months of age, possibly due to atypical increases in attention to non-social stimuli (Ibanez et al., 2008; Maestro et al., 2005; Zwaigenbaum et al., 2005), decreases in attention to social stimuli (Baranek, 1999; Clifford et al., 2007; Maestro et al., 2005; Osterling & Dawson, 1994; Osterling et al., 2002; Watson et al., 2007; Werner et al., 2000; 2005) and longer latencies to disengage and shift attention (Elsabbagh et al., 2009; Zwaigenbaum et al., 2005) during this time period.

The findings from previous studies examining orienting to non-social stimuli are mixed. Baranek (1999) and Osterling et al. (2002) reported that infants later diagnosed with ASD were impaired in orienting to non-social stimuli, while Werner et al. (2005) reported that infants later diagnosed with ASD showed increased attention to objects at 3 to 6 months of age. Similarly,

Zwaigenbaum et al. (2005) reported that longer-than-typical fixations on non-social stimuli at 12 months of age were a behavioural marker predictive of a later diagnosis of ASD. Finally, Maestro et al. (2005) reported that infants later diagnosed with ASD showed a more substantial increase in their attention to objects between 6 and 12 months of age, relative to TD infants. Taken together, it is possible that individuals with ASD are unimpaired in orienting to non-social stimuli, and show a greater increase in attention to non-social stimuli, relative to TD infants, prior to 1 year of age (Maestro et al., 2005). These findings are consistent with the notion of impaired disengagement from non-social stimuli in individuals with ASD (Elsabbagh et al., 2009; Ibanez et al., 2008; Kawakubo et al., 2007; Landry & Bryson, 2004; Zwaigenbaum et al., 2005). The results also indicate that infants later diagnosed with ASD may only orient to non-social stimuli less frequently than other groups of individuals when the stimuli are held by a person (Baranek, 1999; Osterling et al., 2002). The failure of most studies (Baranek, 1999; Maestro et al., 2005) to clearly define whether the stimuli were purely non-social in nature, or whether they contained an additional social component (e.g., being held, worn, or shown by a person) complicates the interpretation of these studies. More research is needed to address this issue.

#### *4.5.5 Limitations of Research Examining Infants Later Diagnosed with ASD*

Studies using retrospective video analysis were confounded by difficulties controlling for situational and contextual variables associated with the video footage. To address this issue, a number of researchers statistically examined whether the video footage obtained for each group differed on potentially confounding variables. Researchers specifically controlled for the location of the footage (Osterling & Dawson, 1994; Werner et al., 2000), the number of participants involved in the interaction (Clifford et al., 2007; Osterling & Dawson, 1994; Osterling et al., 2002; Werner et al., 2000), the number of events depicted (Baranek, 1999), the physical placement of the child (Werner et al., 2000), the amount of time the child was alone (Osterling & Dawson, 1994; Osterling et al., 2002) and the level of social interaction the child was engaged in (Baranek, 1999; Clifford et al., 2007). However, a number of potentially confounding variables failed to be

controlled for in these studies. These included the number of opportunities for social interaction, whether the interactions involved adults or peers, and the quality of social interactions. In addition, Baranek (1999) reported that parents of children with ASD used more compensatory strategies and prompting to engage their child in successful social interactions and play, relative to parents of TD infants. Thus, the extent to which appropriate orienting behaviours were facilitated and prompted by parents or other caregivers needs to be controlled for in future studies.

An additional limitation of studies using retrospective video analysis pertains to difficulties obtaining accurate CA's for participants. While a number of researchers controlled for this variable via the use of video footage from a specific point in time (e.g., first birthday parties; Osterling & Dawson, 1994; Osterling et al., 2002), in other videos, the accuracy of infants' CA may have been compromised by inaccurate parental recall.

Next, it is possible that the video footage provided for analysis was confounded by selection bias and thus failed to provide a random sample of infant behaviour. Parents are more likely to video-tape pleasant situations, positive experiences and special events that they want to remember. Conversely, they are less likely to videotape aversive or uneventful situations. As a result, available video footage may have presented infants in a favourable light and subsequently obscured a number of their behaviours and symptoms (Baranek, 1999).

A major limitation with the use of parent report to assess early social orienting behaviour, pertains to the confounding effects of recall biases and inaccuracies regarding the severity and timing of target behaviours (Zwaigenbaum et al., 2005). These studies were also limited by parents' knowledge of their child's diagnosis and their subsequent sensitivity to related developmental differences.

Finally, many of the studies examining early social orienting behaviours in infants later diagnosed with ASD failed to differentiate between infants who were classified as having an early versus late onset of ASD-related symptomatology (Baranek, 1999; Clifford et al., 2007, Maestro et al., 2005, Osterling & Dawson, 1994). As a result, these studies failed to take account of the



potentially different developmental profiles for these infants and the impact on social orienting behaviours within the first year of life. The finding of impaired social orienting prior to 12 months of age in infants with early onset ASD and unimpaired social orienting in infants with late onset ASD at this age highlights the importance of clearly differentiating between sub-groups of infants with ASD when examining the behavioural markers of ASD prior to 1 year of age.

#### 4.6 Orienting to Social and Non-Social Stimuli in Individuals with ASD

The research described in Section 4.5 provides support for the notion that social orienting impairments in infancy can differentiate infants later diagnosed with ASD from DD and TD infants. Furthermore, the failure to observe impairments orienting attention to non-social stimuli in these studies, suggests that the orienting impairments observed in ASD may be specific to social stimuli. Despite this, studies examining the early behavioural characteristics of ASD in infancy have not directly compared the extent to which social and non-social stimuli capture the attention of individuals with ASD.

Several research studies comparing social and non-social orienting have reported that individuals with ASD demonstrate a specific impairment orienting attention to social stimuli (Klin et al., 2002; Swettenham et al., 1998), while other researchers have failed to find evidence of impaired social orienting in ASD. Three specific methodologies have been utilised in these studies: a comparison of responsivity to social and non-social auditory stimuli, a comparison of visual fixation patterns to social and non-social stimuli, and an analysis of reaction times in response to social and non-social cues to shift and refocus attention.

##### *4.6.1 Research Examining Responsivity to Auditory Stimuli in ASD*

Dawson et al. (1998; 2004) conducted two studies in which social and non-social orienting in children with ASD were directly compared. In the first study, Dawson et al. (1998) presented 20 children with ASD or PDD (Mean CA = 64.6 months), 19 children with Down Syndrome (Mean CA = 65.3 months) and 20 TD children with a series of social and non-social stimuli. Social stimuli

consisted of calling the child's name and clapping hands, and non-social stimuli consisted of a rattle and a musical jack-in-the-box. Participants were matched on receptive language and communication skills, and participants with ASD and DS were additionally matched on CA and VIQ. The results indicated that children with ASD failed to orient to all stimuli more often than other groups of children, and that their orienting impairment was significantly more pronounced for social stimuli. It was additionally reported that when children with ASD oriented to social stimuli, their responses were more delayed than TD children and those with Down Syndrome. However, a limited number of stimuli were used in this study, with only two examples of social and non-social presented to participants. In addition, social stimuli were reportedly more familiar to the children than non-social stimuli. Social and non-social stimuli also differed in their length of presentation, with discontinuous social stimuli and continuous non-social stimuli presented (Dawson et al., 1998; 2004).

Dawson et al. (2004) extended the findings of Dawson et al. (1998) using 72 children with ASD (Mean CA = 43.5 months), 34 children with a DD (Mean CA = 44.8 months) and 39 TD children (Mean CA = 27.1 months), matched on MA. In this study, Dawson et al. (2004) modified their original study to increase the number of social and non-social stimuli utilized, present equivalent numbers of continuous and discontinuous stimuli in each condition, increase the sample size, use a different control group, and ensure social and non-social stimuli obtained equivalent parental ratings of familiarity. Social stimuli consisted of humming, calling the child's name, snapping fingers and slapping hands on thighs. Non-social stimuli consisted of playing a timer beeping, a telephone ringing, a whistle blowing and the sound of a car horn. All stimuli were matched on volume. The results supported those of Dawson et al. (1998), showing that children with ASD were less likely to orient to both social and non-social stimuli than TD and DD children. On the basis of these two studies, Dawson and colleagues (1998; 2004) concluded that children with ASD showed a general impairment in their ability to orient attention, and that their orienting impairment was significantly more pronounced for social stimuli.

#### *4.6.2 Research Examining the Spontaneous Distribution of Visual Attention in ASD*

Other studies have specifically examined whether individuals with ASD differ from TD individuals in the frequency of their attention shifts to, and overall time spent viewing social versus non-social stimuli. In a study using 10 toddlers with ASD (Mean CA = 20.7 months), 17 toddlers with a DD (Mean CA = 19.9 months), and 16 TD toddlers (Mean CA = 20.1 months) matched on CA, Swettenham et al. (1998) examined the spontaneous distribution of attention shifts in a semi-naturalistic setting. Participants with ASD and those with a DD were further matched on NVMA and language skills. In this study, the toddlers were videotaped playing with a selection of toys in the presence of two experimenters and both of their parents. The video footage was then analysed frame-by-frame, in order to determine if the participant was looking at an object, a person's face, or was unfocused. The results indicated that toddlers with ASD looked at people for a lower percentage of time, and objects for a higher percentage of time, relative to TD and DD toddlers. Participants with ASD also fixated on people for significantly shorter average durations, and objects for longer durations than other groups of participants. An analysis of attention shifts showed that toddlers with ASD made fewer overall shifts than TD and DD toddlers, shifted their attention less frequently between categories of stimuli involving people (i.e., between a person and another person, and between an object and a person), and made more attention shifts between objects. The authors concluded that toddlers with ASD did not demonstrate a general impairment shifting attention, however they showed an atypical distribution of attention that was characterized by an impaired ability to shift and maintain attention to social stimuli.

In several other studies, participants were presented with movie or video clips, and their visual fixation patterns to specific regions of interest were analysed. Klin et al. (2002) presented a series of movie clips to 15 high-functioning adolescents with ASD (Mean CA = 15.4 years) and 15 TD adolescents (Mean CA = 17.9 years) individually matched on CA and VIQ. The results showed that participants with ASD spent significantly more time fixated on objects, and the mouth and body regions of the protagonists, and significantly less time fixated on the eye region relative to TD

participants. The authors further reported that reduced fixations to the eye region were the best predictor of an ASD diagnosis. Similar results were obtained by Norbury et al. (2009) who reported that adolescents with ASD (Mean CA = 14.9 years) oriented to the eye region of protagonists engaged in social interaction, significantly less frequently than CA and NVIQ-matched TD participants (Mean CA = 14.50 years).

Jones, Carr, and Klin (2008) examined the eye movements of 2-year-old children with ASD, NVIQ and CA-matched TD children, and VMA and CA-matched DD children while viewing an adult depicted in a video clip engaging in child-centred speech and social games. Children with ASD fixated on the eye region of the adult depicted in the video clip for a significantly lower percentage of time, and the mouth region for a significantly higher percentage of time than TD and DD children. Finally, using the same movie clips as Klin et al. (2002), Speer et al. (2007) examined the visual fixation patterns 12 children and adolescents with ASD (Mean CA = 13.6 years), and 12 TD adolescents (Mean CA = 13.3) matched on VIQ and PIQ. In this study, video clips were classified according to the nature (i.e., static versus dynamic) and social complexity (i.e., isolated versus social) of the scenes, creating four categories of stimuli: isolated static, isolated dynamic, social static, and social dynamic. Video clips were classified as 'isolated' if one person was present in the scene and 'social' if two or more people were depicted. Participants' visual fixations to objects, or the eyes, mouth, body, or face of the protagonists were recorded. The results showed that participants with ASD spent significantly less time fixated on the eye region, and more time fixated on the body region than TD adolescents in the social dynamic condition. Group fixation patterns did not differ for any other category of stimuli. Speer et al. concluded that social orienting deficits observed in individuals with ASD may only be observed under conditions in which the individual is viewing stimuli that are realistic, dynamic, and social in nature.

Evidence of impaired social orienting in individuals with ASD has also been found in studies examining visual fixation patterns to pictures depicting social and non-social stimuli. Riby and Hancock (2008) presented photographs of social scenes to 20 participants with ASD (Mean

CA = 13.04 years), pair-matched to TD participants on CA (Mean CA = 13.03 years), and NV ability. The results showed that there were no group differences in the time spent viewing the background of the scene or the bodies of the human actors, however, participants with ASD spent significantly less time viewing the face of the human actor, relative to control subjects. Further analysis of visual fixations to the facial region revealed that there were no group differences in the proportion of time spent viewing the mouth area, however, participants with ASD spent significantly less time viewing the eye region than TD participants.

Using the same participants, Riby and Hancock (2009a) examined visual fixation patterns to a variety of static images and movie extracts presented on a computer screen. Results indicated that, for all types of stimuli, individuals with ASD spent less time looking at the face region than TD individuals. Further analyses of visual fixation patterns to the facial area showed that individuals with ASD spent less time fixating on the eye region, however, they did not differ from TD participants in the percentage of time fixated on the mouth region. They also spent more time fixated on background region than CA but not NV-matched participants. Finally, participants with ASD spent more time fixated on the body region than both control groups when viewing cartoon pictures, however they only spent more time fixated on the body region than CA-matched participants when viewing movies with human actors, and more time than NV-matched participants when viewing and cartoon movies. These findings were supported in a subsequent study by Riby and Hancock (2009b) who reported that participants with ASD took significantly longer to fixate on facial images embedded in greyscale photographs and scrambled images of naturalistic scenes. Participants with ASD additionally made fewer fixations to the facial region, and fixated on the facial region for significantly shorter durations than TD participants.

However, other studies examining the visual fixation patterns of individuals with ASD to pictures have obtained mixed results, or found no evidence of impaired social orienting in these participants. For example, Van der Geest et al. (2002) presented cartoon-like scenes depicting social and non-social information to 16 children with ASD (Mean CA= 10.6 years) and 14 FSIQ-

matched TD children (Mean CA = 9.9 years). Children with ASD did not differ from TD children in their visual fixation patterns at a general level, nor did they show a specific deficit orienting to social stimuli. Similarly, Fletcher-Watson et al. (2009) presented 12 high-functioning individuals with ASD (Mean CA = 18.8 years) and 15 CA-matched TD individuals (Mean CA = 21.5 years) with a series of pairs of scenes on a computer screen. One scene in each pair depicted a person, while the other scene did not contain any social information. There were no group differences in the proportion of time spent viewing the social versus non-social scenes. Both groups of participants preferentially attended to the social scene, and the social stimuli (person) within the scene. Within the social scene, there were no group differences in the proportion of viewing time spent attending to the background of the scene, or person depicted in the scene. Further examination of the distribution of attention between different aspects of the person in the scene revealed that all participants viewed the body and face of the person for equal amounts of time, however participants with ASD showed a subtle tendency to spend less time viewing both the body and face of the person overall, relative to TD participants. Finally, groups did not differ on the proportion of time they spent viewing the eyes versus the remainder of the person's face in the scene. An analysis of first fixations showed that while both groups of participants made more fixations to the social than non-social scene, participants with ASD made significantly fewer first fixations to the social scene, and more fixations to the non-social scene than TD participants. Participants with ASD additionally made significantly fewer first fixations to the person, and to the person's face within the social scene than control subjects. The authors concluded that participants with ASD demonstrated similar viewing patterns to TD participants overall, and did not show an aversion to social stimuli; however, were less likely than TD individuals to orient to social stimuli at the first visual fixation.

Finally, the notion of unimpaired social orienting behaviour in individuals with ASD was supported by Fletcher-Watson, Leekam, Findlay, and Stanton (2008) who, using a change blindness paradigm, examined whether adults with ASD (Mean CA = 18.72 years) differed from

CA, gender, and IQ-matched TD adults in the speed with which they detected changes in the eye gaze direction of faces depicted in naturalistic scenes, relative to non-social control changes (i.e., the presence or absence of glasses). The results indicated that adults with ASD were unimpaired in their ability to detect changes in eye gaze. Adults with ASD did not differ from TD adults in the speed with which they detected changes in eye gaze, and both groups of participants were faster to detect changes in eye gaze than non-social control changes.

#### *4.6.3 Summary of Research Examining Social and Non-Social Orienting in ASD*

In summary, a number of studies have examined whether individuals with ASD differ from non-autistic individuals in the frequency and distribution of their attention to social and non-social stimuli. Several researchers have reported that socially relevant information fails to attract the attention of individuals with ASD in the same manner as other groups of participants, providing support for the notion of impaired social orienting in ASD. Studies examining responsivity to auditory stimuli showed that participants with ASD oriented to auditory stimuli more slowly and less consistently than TD and DD participants, and that the orienting impairment was considerably more pronounced for social stimuli (Dawson et al., 1998; 2004). Likewise, research examining spontaneous visual fixation patterns to social and non-social stimuli showed that individuals with ASD oriented to social stimuli less frequently (Klin et al., 2002; Riby & Hancock, 2009b; Swettenham et al., 1998), oriented to non-social stimuli more frequently (Klin et al., 2002; Swettenham et al., 1998), showed longer fixations to non-social stimuli (Klin et al., 2002; Riby & Hancock., 2009a; Swettenham et al., 1998) and shorter fixations to social stimuli (Klin et al., 2002; Riby & Hancock, 2008; 2009a; 2009b; Speer et al., 2007; Swettenham et al., 1998) relative to other groups of participants. In one study, participants with ASD also showed longer latencies between the onset of the stimulus and the first fixation to the human face within a social scene (Riby & Hancock, 2009b), and, in another, showed a preference for attention shifts involving categories of non-social stimuli (i.e., objects; Swettenham et al., 1998).

When viewing a social stimulus (e.g., a person), participants with ASD also showed an atypical distribution of attention between different socially informative regions of the face. They showed a lack of spontaneous gaze towards the eye region (Klin et al., 2002; Riby & Hancock, 2008; 2009a; Speer et al., 2007) and spent a significantly higher proportion of time viewing the mouths and bodies of characters relative to TD comparison groups (Klin et al., 2002; Riby & Hancock, 2009a; Speer et al., 2007). The notion that individuals with ASD demonstrate atypical viewing patterns to social stimuli (e.g., people) is consistent with recent research indicating that these individuals fail to demonstrate the same preferential attention to biological motion (e.g., facial expressions, eye gaze) observed in TD infants and children, and instead direct their attention to less- or non-social aspects of stimuli with high audiovisual synchrony (e.g., hands clapping or mouth movements with speech; Klin et al., 2009). Abnormal gaze behaviour towards human faces in individuals with ASD was observed using stimuli depicting both single and multiple people in static scenes (Riby & Hancock, 2008; 2009a; 2009b), and in video clips depicting intense social interactions (Klin et al., 2002; Riby & Hancock, 2009a; Speer et al., 2007).

In other studies, however, findings were mixed (Fletcher-Watson et al., 2009; Speer et al., 2007). In one study, children with ASD preferentially attended to the social scene and the person within the social scene, however they showed a reduced salience and priority for social stimuli at the first fixation (Fletcher-Watson et al., 2009). In another study, participants with ASD only showed impaired social orienting when presented with video clips depicting intense social interactions between multiple people (Speer et al., 2007). Finally, Van der Geest et al. (2002) reported that participants with ASD did not differ from other groups of participants in their preferential attention to social stimuli depicted in a scene. Orienting to the eye, object or body regions was not found to be associated with CA (Klin et al., 2002; Riby & Hancock, 2009a; 2009b; Speer et al., 2007; Van der Geest et al., 2002) verbal ability (Jones et al., 2008; Klin et al., 2002; Norbury et al., 2009; Speer et al., 2007) or non-verbal ability (Dawson et al., 1998; Fletcher-



Watson et al., 2009; Jones et al., 2008; Norbury et al., 2009; Riby & Hancock, 2009a; Speer et al., 2007; Van der Geest et al., 2002) in these studies.

A number of researchers have proposed that discrepancies with the aforementioned findings may be accounted for by the characteristics of the stimuli presented (Klin et al., 2002; Riby & Hancock, 2009a; Speer et al., 2007). Specifically, visual fixation patterns in individuals with ASD may be influenced by the extent to which the social components of the stimuli parallel naturalistic social interactions (Klin et al., 2002). According to this view, the gaze behaviour of individuals with ASD may be more typical when presented with stimuli with reduced ecological validity such as photographs or drawings (Klin et al., 2002; Speer et al., 2007). This is consistent with the failure to find group differences in social orienting behaviour when participants were presented with cartoons (Van der Geest et al., 2002) or photographs (Fletcher-Watson et al., 2009; Speer et al., 2007) depicting social information. Drawings and pictures are inherently different from the social stimuli encountered during social interactions with others and may therefore elicit different gaze behaviour.

Conversely, individuals with ASD may be less engaged by more ecologically valid stimuli that encapsulates the complexity of real life social interactions. As a result, more pronounced atypicalities in gaze behaviour may be observed when viewing moving and complex social information accompanied by sound and language. This is consistent with the findings of Klin et al. (2002) and Speer et al. (2007), who examined gaze behaviour using movie clips depicting four people engaged in an intense social exchange, and Swettenham et al. (1998) who examined social orienting in a semi-naturalistic setting. Similarly, Riby and Hancock (2009a) observed abnormal fixations to social stimuli in individuals with ASD using both cartoon and human movies depicting interactions between one to four people. Consistent with this notion is the failure of Speer et al. to find group differences using dynamic movie clips containing a single person. Taken together, these results indicate that atypical gaze behaviour in individuals with ASD may be particularly pronounced when presented with multiple individuals interacting in a dynamic scene.

While there is evidence to suggest that stimulus type and content impacts on the gaze behaviour of individuals with ASD, this factor fails to account for a number of findings. Several researchers have documented abnormal gaze behaviour individuals with ASD using stimuli that lack ecological validity and social complexity (Riby & Hancock, 2008; 2009a). Atypical social orienting behaviour to photographs (Riby & Hancock, 2009a) and static images of cartoon characters (Riby & Hancock, 2008) has been reported. This is further complicated by numerous studies documenting impaired face processing in individuals with ASD using stimuli depicting a single face (Dalton et al., 2005; Faja, Webb, Merkle, Aylward, & Dawson, 2009; Neumann, Spezio, Piven, & Adolphs, 2006; Pelphrey et al., 2002; Spezio, Adolphs, Hurley, & Piven, 2007). While the social complexity and relevance of the stimuli may contribute to the discrepancies in the aforementioned findings, it is likely that other variables associated with the nature of the stimulus also need to be considered. These include the intensity of the social interaction depicted, whether the stimuli feature direct or indirect gaze, and the size and relative salience of social versus non-social stimuli depicted in the stimuli.

Another factor that may account for the discrepancies in the aforementioned findings pertains to the specific characteristics of participants. Specifically, gaze behaviours may be less impaired in participants with less severe ASD-related symptomatology. In support, a number of researchers have established a negative correlation between the length of face gaze and participants' level of functioning on the autistic spectrum as determined by their CARS score (Klin et al., 2002; Riby & Hancock, 2009a; 2009b), or their level of social responsiveness as measured by the Social Responsiveness Scale (SRS; Constantino & Gruber, 2005) (Speer et al., 2007). Individuals with less-severe autistic symptomatology spent more time fixated on faces than those with relatively higher levels of autistic symptomatology. This finding is likely to account for some of the differences between the findings of the aforementioned studies. Participant characteristics are therefore an important factor when drawing conclusions about the gaze behaviour of individuals with ASD.

Another key finding to emerge from studies examining social orienting behaviours in individuals with ASD is that they show an atypical distribution of attention between different regions of the face. Overall, these individuals spend less time fixating on the eye region and more time on less socially-informative regions of the face such as the mouth region (Klin et al., 2002). This finding is consistent with several other studies (Corden, Chilvers, & Skuse, 2008; Dalton et al., 2005; Joseph & Tanaka, 2003; Klin et al., 2002; Neumann et al., 2006; Spezio et al., 2007), and research suggesting that individuals with ASD spend less time looking at core features of the face (e.g., eyes and nose), and more time looking at other areas such as the chin, cheeks and side of the face (Pelphrey et al., 2002; Trepagnier, Sebrechts, & Peterson, 2002).

The notion of impaired face processing in ASD is further supported by research showing that individuals with ASD are impaired in recognizing and identifying facial expressions (Klin et al., 1999; Trepagnier et al., 2002) and distinguishing between familiar and unfamiliar faces (Joseph & Tanaka, 2003). Researchers have also suggested that face processing atypicalities in ASD extend beyond facial recognition to the perceptual discrimination of faces (Behrmann, Thomas, & Humphreys, 2006). Evidence suggests that individuals with ASD rely on local details of the face for processing rather than on the overall configuration of features (Behrmann, Thomas et al., 2006; Joseph & Tanaka, 2003), and process faces using areas of the brain typically involved in processing non-social stimuli (Hall et al., 2003; Schultz et al., 2000). Neumann et al. (2006) proposed that abnormal face processing in individuals with ASD results from atypical top-down modulation of attentional processes as opposed to a heightened sensitivity to the bottom-up saliency of features such as the mouth region. The face processing impairment observed in individuals with ASD is reportedly not related to impaired visual discrimination (e.g., Chawarska, Klin, & Volkmar, 2003) or cognitive abilities (Klin et al., 1999).

#### *4.6.4 Limitations of Research Examining Social and Non-Social Orienting in ASD*

The majority of the previous studies examining social orienting in ASD examined orienting behaviour in a highly controlled laboratory setting. This allowed for a more accurate

measurement of eye gaze, and enabled the effect of specific extraneous variables to be eliminated or reduced; however, it did not allow for the examination of eye gaze behaviour in an ecologically valid social setting.

Additionally, social and non-social stimuli were not matched on their degree of familiarity (Dawson et al., 1998) or extent to which they captured the attention of participants. The extent to which the stimuli utilized in many of these studies were good representations of naturally occurring social stimuli is also questionable. Dawson and colleagues (1998; 2004) presented stimuli in discrete trials to participants, thus failing to reflect the continuous stream of information presented in the naturalistic setting. Furthermore, the extent to which snapping fingers and slapping hands on thighs elicit the same response as other socially-relevant stimuli is questionable, and the potential impact of the physical movement associated with these stimuli was not accounted for. Other studies presented participants with still pictures or movies depicting social stimuli. Thus, the extent to which the observed visual fixation patterns reflected those elicited in a naturalistic social setting is unclear. Assessing gaze behaviour in a naturalistic and socially valid context is particularly important in light of the evidence suggesting that visual fixation patterns in individuals with ASD may be influenced by the characteristics of the stimulus to be viewed (Landry & Bryson, 2004).

The results of studies measuring overt eye movements may also be confounded by perceptual and attentional abnormalities. Abnormal eye movements in ASD have been reported in some studies (Luna et al., 2007; Takarae, Minshew, Luna, Krisky et al., 2004; Takarae, Minshew, Luna, & Sweeney, 2004), but not others (Minshew et al., 1999; Nowinski et al., 2005). As a result, the extent to which observed deficits are due to impairments in oculomotor functions, social orienting, or both, requires further investigation.

Finally, the wide variation of stimuli used in these studies makes comparisons difficult. Variables such as the number of participants, and the quality and complexity of the social interaction depicted in the stimuli, whether the stimuli was moving or static, and whether direct or

indirect eye gaze was featured differed across stimuli. As a result, the extent to which these variables impacted on the orienting behaviour of participants is unclear.

#### 4.7 Research Examining Gaze Shifts in response to Social and Non-Social Cues

The ability to follow another person's eye gaze is an early-emerging social-cognitive skill that allows for the establishment of triadic JA (Swettenham, Condie, Campbell, Milne, & Coleman, 2003). By 9 months of age, TD infants follow another person's head-turn to search for an object (Corkum & Moore, 1998), and by 18 to 24 months of age, TD toddlers are able to reliably follow the direction of another person's eye movements (Kylliainen & Hietanen, 2004; Senju et al., 2004; Swettenham et al., 2003; Vlamings et al., 2005).

A number of studies have examined whether children with ASD are impaired in their ability to follow the gaze of another person (Chawarska et al., 2003; Leekam et al., 1998; Swettenham et al., 2003). In TD children, gaze direction is a highly salient stimulus that triggers a reflexive shift of attention. However, the findings are mixed for children with ASD. While several researchers have reported that individuals with ASD are impaired in their ability to reflexively shift attention in response to eye gaze cues (Baron-Cohen, Baldwin, & Crowson, 1997; Baron-Cohen, Campbell, Karmiloff-Smith, Grant, & Walker, 1995; Leekam et al., 1998; Ristic et al., 2005), others have failed to find evidence of impairment (Chawarska et al., 2003; Kylliainen & Hietanen, 2004; Swettenham et al., 2003). However, the absence or presence of an impaired ability to reflexively shift attention in response to eye gaze cues appears to be strongly influenced by cognitive ability, with convergent evidence suggesting that high-functioning individuals with ASD are able to spontaneously shift attention in response to the eye gaze cues of another (Fletcher-Watson, Leekam, Findlay, & Stanton, 2008; Leekam et al., 1998; Swettenham et al., 2003).

In order to further examine reflexive orienting to eye gaze cues in individuals with ASD, several studies have directly compared the extent to which individuals with ASD and TD individuals reflexively shift their attention in response to eye gaze and arrow cues using variants of

Posner's spatial cueing task. Vlamings et al. (2005) examined the ability of 19 adults with ASD and 19 neurotypical adults to orient attention to a target stimulus preceded by non-predictive directional eye gaze cues (depicted in photographs of faces) and symbolic arrow cues. Groups were matched on CA. Results indicated that TD adults demonstrated longer reaction times to eye gaze cues than arrow cues, suggesting that eye gaze cues were more salient than symbolic (arrow) cues. This finding was supported in a recent study of TD adults (Hietanen, Nummenmaa, Nyman, Parkkola, & Hämäläinen, 2006). Conversely, participants with ASD did not differ in their reaction times to eye gaze or symbolic cues. These findings are consistent with Chawarska et al. (2003), who reported that toddlers with ASD responded more quickly to eye gaze cues than TD toddlers; however, they did not differ from TD toddlers in their response times to non-social cues. The general interpretation of these findings is that these social (i.e., eye-gaze) and non-social (i.e., arrow) cues may have equal salience or importance for individuals with ASD, and that eye gaze may be processed in the same manner as non-social symbolic cues such as arrows. However, for TD children, more time is needed to process eye gaze cues due to their enhanced social salience (Chawarska et al., 2003; Vlamings et al., 2005).

The notion that individuals with ASD process social cues atypically was supported by Senju et al. (2004). In this study, 26 children with ASD (Mean CA = 9.6 years), and 38 age-matched TD children (Mean CA = 9.6 years) were presented with non-predictive eye cues (depicted in photographs of faces) and arrow cues, and instructed that the target would appear at the opposite location indicated by the cue. Results indicated that TD children inhibited automatic cueing to the (incorrect) direction of the cue in the arrow condition, but not the gaze condition. This finding was supported in other recent studies (Friesen, Ristic, & Kingstone, 2004; Ristic, Wright, & Kingstone, 2007). In contrast, children with ASD did not differ in their ability to inhibit orienting to the (incorrectly) cued location in either condition. These findings support the notion that individuals with ASD fail to demonstrate a preferential salience, and sensitivity to social, relative to non-social cues.

However, other studies have reported that individuals with ASD do not differ from TD individuals in their response to eye gaze cues (Kylliainen & Hietanen, 2004; Swettenham et al., 2003). In a recent study, Kuhn et al. (2009) used a Posner type cueing task (Posner, 1980) to examine overt orienting in response to non-predictive eye gaze cues (depicted in schematic drawings of faces) and arrow cues in 12 adults with ASD and 12 TD adults matched on CA, VIQ, PIQ and FSIQ. The results revealed that adults with ASD did not differ from TD adults in their responses to eye gaze and arrow cues. Kuhn et al. concluded that, when presented with schematic stimuli, attentional orienting in response to eye gaze and arrow cues is typical in individuals with ASD.

Taken together, these studies suggest that some individuals with ASD fail to exhibit the same preferential sensitivity to social cues observed in TD participants; demonstrating similar cueing effects in response to eye gaze and arrow cues (Senju et al., 2004; Vlamings et al., 2005). The lack of preferential sensitivity to eye gaze cues in individuals with ASD is consistent with previous research indicating that these individuals fail to demonstrate preferential attention to socially salient features of the face (e.g., the eye region; Pelphrey et al., 2002) or to socially-relevant information in movies or pictures (Klin et al., 2002; Norbury et al., 2008), as is observed in TD individuals. The failure of other studies (e.g., Kuhn et al., 2009; Kylliainen & Hietanen, 2004; Swettenham et al., 2003) to find group differences in the cueing effects of eye gaze and arrow cues, suggests that individuals with ASD demonstrate ‘typical’ gaze cueing effects under some conditions. However, the factors that influence attentional cueing in individuals with ASD remain unclear. The majority of studies reporting atypical responses to eye gaze and arrow cues in individuals with ASD utilized realistic photographs of faces (e.g., Chawarska et al., 2003; Senju et al., 2004; Vlamings et al., 2005), as opposed to stimuli with reduced ecological validity (e.g., schematic drawings). However, other studies have documented typical gaze cueing effects using realistic photographs of faces (e.g., Kylliainen & Hietanen, 2004; Swettenham et al., 2003). Atypical gaze cueing effects have also been documented in studies using both adults (Vlamings et al., 2005)

and children (Chawarska et al., 2003; Senju et al., 2004) with ASD. Thus, the factors that impact on the attentional cueing of individuals with ASD remain unclear.

#### *4.7.1 Limitations of Research Examining Gaze Shifts in response to Social and Non-Social Cues*

Several limitations pertaining to the previous studies examining orienting attention to social and non-social cues in ASD were discussed in Section 4.6.4. In particular, the stimuli utilized in studies examining responses to eye gaze and arrow cues lacked ecological validity. Stimuli consisted of schematic drawings of photographs of faces, rather than real-life faces, and the attentional cues were presented a computer screen without a situational or social context. In addition, several researches have reported that the ability to reflexively shift attention in response to eye gaze cues is mediated by cognitive ability. However, while participants in both Vlamings et al. (2005) and Senju et al. (2004) were reportedly high-functioning, no measure of cognitive ability was utilized in these studies, nor was the relationship between IQ and orienting skills examined for these participants. Nevertheless, as participants with reportedly normal-to-above-normal cognitive ability were utilized in these studies, the extent to which these findings can be generalized to younger or lower functioning individuals is unclear.

### 4.8 The Amygdala and Social Orienting in ASD

Amygdala dysfunction has been implicated in the failure to assign reward value to social stimuli in individuals with ASD. Schultz (2005) proposed that dysfunction of the amygdala in infancy then hinders the development of social behaviour, and constrains the development of other regions of the ‘social brain’ such as the fusiform gyrus for face recognition and perception (Dalton et al., 2005; Hadjikhani et al., 2006; Johnson et al., 2005; Kleinhans et al., 2008; 2009; Schultz, 2005). The interaction between impaired social orienting and deficits in neural development leads to a cascade of impairments that underlie the deficits observed in individuals with ASD.

The amygdala is a collection of nuclei located in the medial temporal lobe (Nacewicz et al., 2006; for full description see Baron-Cohen et al., 2000). A number of researchers have proposed



that it plays an important role in the mediation of social behaviour (Dalton et al., 2005; Nacewicz et al., 2006; Schultz, 2005). In particular, the amygdala has been linked to the detection and response to potentially threatening stimuli (Amaral, Bauman, & Schumann, 2003), face processing (Grelotti et al., 2002), the interpretation of gaze, emotions, and mental states (Adolphs et al., 2005; Corden et al., 2008; Nacewicz et al., 2006; Shaw et al., 2004), emotional memory (LaBar, 2007), and the ability to orient attention to the eye region of the face (Corden et al., 2008; Dalton et al., 2005; Schultz, 2005). The amygdala is also critical in establishing the affective significance or salience of stimuli or an event (Dawson, Munson et al., 2002; LaBar, 2007), and mediates the development of visual-reward associations or ‘emotional learning’ (LaBar, 2007). As a result, congenital abnormalities of the amygdala in individuals with ASD could result in reduced attention to social stimuli and faces in the first few months of life (Maestro et al., 2002).

While the results of studies examining amygdala structure and function in ASD are inconsistent, converging evidence suggests that amygdala growth patterns may be atypical in individuals with ASD. MRI studies of TD children have shown that the amygdala systematically increases in volume and reaches adult size in late-adolescence (Schumann et al., 2004). In contrast, amygdala growth in individuals with ASD is characterized by excessive growth in early childhood, with no further growth evidenced after approximately 8 years of age (Mosconi et al., 2009; Schumann et al., 2004; Sparks et al., 2002). Other studies have reported that individuals with ASD show atrophy of the amygdala in late-adolescence and early-adulthood (Nacewicz et al., 2006; Schumann et al., 2004), leading to reduced amygdala volume in adulthood (Kleinhans et al., 2008; Nacewicz et al., 2006; Pierce et al., 2001). In one study, however, no differences were observed in the amygdala volume of individuals with ASD and control subjects (Haznedar et al., 2000).

Further evidence for amygdala abnormalities have been found in recent studies utilizing functional neuroimaging and also in post-mortem analysis. Atypical blood flow and activation during face viewing or mentalizing tasks (Ashwin, Chapman, Colle, & Baron-Cohen, 2006; Critchley et al., 2000; Dalton et al., 2005), and increased cell density and reduced neuronal size

post-mortem, have been reported in individuals with ASD (Schumann & Amaral, 2006).

Biochemical abnormalities have also been identified (Page et al., 2006). Taken together, these findings provide strong convergent evidence for the presence of amygdala abnormalities in ASD.

The relationship between amygdala abnormalities and level of clinical impairment in ASD has been examined in a number of recent studies. Abnormalities of the amygdala have been related to an impaired ability to orient visual attention to the eye region of the face (Corden et al., 2008; Dalton et al., 2005), and interpret emotions and mental states (Ashwin et al., 2006; Baron-Cohen et al., 2000; Corden et al., 2008; Nacewicz et al., 2006; Shaw et al., 2004). Munson et al. (2006) established a relationship between enlarged right amygdala volume and level of social and communicative impairment on the ADI-R (Rutter et al., 2003) at 3 to 4 years of age. Results further showed that enlarged right amygdala volume was predictive of more severe social and communicative impairments at 6 years of age. In another study, Mosconi et al. (2009) reported that enlarged amygdala volume at 2 years of age was related to impaired JA skills by 4 years of age. Finally, Nacewicz et al. (2006) examined the relationship between amygdala volume and impairments in social orienting, emotional processing and social impairment as measured by the ADI-R (Rutter et al., 2003). Twenty-eight individuals with ASD, aged from 8 to 25 years ( $M = 16.8$  and  $14.3$  years for experiments 1 and 2 respectively) and 26 TD individuals matched on CA ( $M = 17.0$  and  $13.7$  years for experiments 1 and study 2 respectively) participated in the study. Results indicated that adolescents and adults with the smallest amygdala volumes showed reduced fixations to the eye region, slowed processing of emotions, and impaired non-verbal social behaviours. This relationship was not observed for TD individuals.

It has been proposed that the developmental abnormalities in the amygdala may stem from the excessive firing of neurons (i.e., hyper-excitability) in individuals with ASD when presented with social stimuli (Dalton et al., 2005; Hirstein, Iversen, & Ramachandran, 2001; Kleinhans et al., 2008; Nacewicz et al., 2006). In particular, researchers have proposed that hyperactivity in the amygdala causes excitotoxic changes that may play a role in its early overgrowth and eventual

shrinkage (Nacewicz et al., 2006). While the direction of causality remains unclear, a number of researchers have proposed that hyper-excitability of the amygdala plays a role in the behavioural deficits observed in ASD (Schultz, 2005). Specifically, an association between amygdala hyperactivity and a fear response have been established in animal research (McEwen, 2003). As a result, it has been proposed that amygdala hyper-excitability in response to social stimuli, may trigger fear and anxiety in individuals with ASD when viewing facial stimuli (Dalton et al., 2005). This, in turn, may cause these individuals to avoid social stimuli and avert their gaze away from the face and eyes. This notion is consistent with recent research showing that children with ASD show stronger skin conductance responses than TD children to direct gaze compared with averted eye gaze (Kylliäinen & Hietanen, 2006). Enhanced physiological arousal to eye-contact in children with ASD may lead to decreased motivation to establish eye-contact with others, thereby contributing to their lack of neural specialisation for face processing (Kylliäinen & Hietanen, 2006).

Other researchers have shown that when presented with pictures of faces, brain activation of adults with ASD remains higher for significantly longer than TD adults. As decreased activation over time is indicative of neural habituation and learning (Kleinhans et al., 2008; 2009), the sustained arousal of the amygdala in individuals with ASD may indicate a failure to habituate to human faces. Kleinhans et al. (2008; 2009) concluded that this leads to difficulties adapting to social stimuli which may, in turn, contribute to the deficits in both social interaction and social cognition observed in individuals with ASD. This is consistent with atypical electrical brain wave activity during facial, but not object recognition tasks, in children with ASD (Dawson, Carver et al., 2002).

While evidence suggests that abnormalities within the amygdala play a role in the social orienting deficits observed in ASD, the exact nature of the relationship remains unclear. According to one model, early-developing atypicalities in neural structures such as the amygdala lead to the social orienting deficits observed in individuals with ASD (Schultz, 2005). An alternative

hypotheses, however, proposes that deficits in social orienting and face processing are a result of having ASD and occur via an unknown mechanism. Reduced social orienting in infancy then leads to a cascade of abnormalities in neural processes and structures necessary for normal social behaviour, resulting in the social deficits characteristic of ASD (Dawson, Webb, & McPartland, 2005; Dawson, Webb, Wijsman et al., 2005). While these theories differ in the direction of causality, they both conclude that impaired social orienting early in life plays a critical role in the social deficits observed in ASD.

#### *4.8.1 Summary of Research Examining the Amygdala and Social Orienting in ASD*

Several researchers have suggested that the social orienting deficit in ASD is related to atypicalities in both the volume and neuronal activity of the amygdala. Excessive growth patterns in early-childhood (Schumann et al., 2004; Sparks et al., 2002), followed by smaller volumes by late adolescence (Nacewicz et al., 2006; Schumann et al., 2004) have been supported in a number of studies. These abnormalities have been attributed to excitotoxic changes resulting from amygdala hyper-excitability in individuals with ASD (Dalton et al., 2005; Hirstein et al., 2001; Kleinhans et al., 2008; Nacewicz et al., 2006), and have been linked to a number of facets of autistic symptomatology, including impairments in social orienting, emotion perception and social behaviour (Ashwin et al., 2006; Corden et al., 2008; Dalton et al., 2005; Mosconi et al., 2009; Munson et al., 2006; Nacewicz et al., 2006).

#### *4.8.2 Limitations of Research Examining the Amygdala and Social Orienting in ASD*

Research examining the relationship between amygdala function and ASD symptomatology has been hindered by a number of factors. These include the wide age range of participants, considerable variation in the severity of autistic symptomatology, and different neuroimaging regions and procedures (Munson et al., 2006; Schumann et al., 2004). As these variables have varied considerably across studies, the extent to which they have influenced the results remains unclear.

Finally, a major limitation with the proposed relationship between amygdala atypicalities and the social deficits observed in ASD is the finding that other individuals with amygdala impairments or lesions do not show autistic symptomatology. Instead, pure amygdala abnormalities principally affect fear and anxiety processes, leaving most social behaviours unaffected (Amaral et al., 2003). Consistent with this notion, the right amygdala of individuals with a Generalized Anxiety Disorder is reportedly 16% larger than TD individuals (De Bellis et al., 2000). Thus, the exact role of amygdala atypicalities in the social deficits observed in ASD warrants further investigation.

#### 4.9 Unresolved Issues

Several lines of research question the extent to which ASD symptomatology can be explained by an impaired ability to orient to social stimuli. First, atypical processing of non-social stimuli has been documented in ASD. An enhanced ability to process the featural or local elements of visual (Morgan et al., 2003; Plaisted et al., 1999) and auditory stimuli (Mottron et al., 2000), as well as superior memory for concrete information (Attwood, 1998; Vermeulen, 2001) have been documented (see Chapter 2, Section 2.3 for WCC theory of ASD).

Similarly, information processing deficits when required to process complex, novel non-social forms of stimuli are well documented in individuals with ASD. Previous research studies have shown that individuals with ASD are impaired in processing complex, multisensory or novel stimuli (Iarocci & McDonald, 2006; Minshew et al., 2002; Williams, Goldstein, & Minshew, 2006b). Other researchers have reported that individuals with ASD process stimuli more slowly than TD individuals (Bogte et al., 2008), or are impaired in their attentional prioritization of dynamic and transient stimuli (Keehn & Joseph, 2008; Pellicano et al., 2005). The notion that ASD may be characterized by information processing limitations is further supported by neurological research documenting an excess of unnecessary short-distance connections and a relative scarcity of long-distance connections necessary for higher-level processes in the neocortex of individuals

with ASD; possibly resulting in slowed, inefficient processing of information (Bogte et al., 2008; Courchesne & Pierce, 2005; Courchesne, Redcay, Morgan, & Kennedy, 2005; Just, Cherkassky, Keller, Kana, & Minshew, 2007).

Additionally, several theorists have proposed that complex, novel stimuli lead to an increase in the physiological arousal of children with ASD. According to this view, TD individuals orient more frequently to novel, unpredictable and 'interesting' stimuli; with stimuli that deviates from this range of novelty or predictability eliciting an aversive response or no response. However, for individuals with ASD, arousal modulation may be impaired, resulting in a more narrow range of optimal stimulation and a lower aversion threshold for these individuals (Dawson & Levy, 1998). Consistent with this, several researchers have demonstrated that the frequency, duration and intensity of stereotyped, self-stimulatory behaviours increase when the complexity of the environment increases (Raymaekers, van der Meere, & Roeyers, 2004). Accelerated heart rates, difficulties habituating responses to novel stimuli (Dawson & Levy, 1998) and differences in the brain wave activity of individuals with ASD in response to novel stimuli (Sokhadze et al., 2009) have also been documented.

As the social and non-social stimuli in the studies described in Section 4.6 were not of comparable complexity; with the social stimuli significantly more complex than the non-stimuli presented, the extent to which the social orienting impairment observed in individuals with ASD stems from an impaired ability to orient to social stimuli, or difficulties processing highly complex stimuli requires further investigation.

Finally, several researchers have proposed that social orienting impairments stem from a lack of social motivation in individuals with ASD (Dawson, Webb, & McPartland, 2005). However, evidence suggests that there are individuals with HFA or AsD who have a strong desire to form friendships and understand social situations, reporting feelings of loneliness in the absence of such friendships (Bauminger & Kasari, 2000; Bauminger et al., 2003; Birch, 2003).

#### 4.10 Chapter Summary and Conclusions

The current chapter summarized the social orienting literature for individuals with ASD. The notion of a specific impairment orienting attention to social stimuli was supported in a number of studies. Specific findings included decreased attentional capture of social, relative to non-social stimuli, less frequent orienting and reduced fixation times to social stimuli, and impaired exogenous orienting to social cues, but not to objects for participants with ASD. Other studies reported that when individuals with ASD oriented to social stimuli, they did so at a slower rate, for shorter durations, and focused on different aspects of the stimuli than other groups of participants. Individuals with ASD also made fewer shifts of attention between social stimuli, and engaged in less visual exploration of social stimuli relative to TD and DD comparison groups. While it is unclear whether social orienting impairments in ASD are at the level of exogenous or endogenous orienting, or both, it is possible that social stimuli hold less salience for individuals with ASD and thus fail to capture their attention to the same extent as TD individuals. However, social orienting impairments also appear to be influenced by the nature of the stimuli to be processed, with the greatest orienting impairments observed for more socially-complex stimuli. More research is needed to examine this issue. In order to understand the role of social and non-social orienting in autistic symptomatology, the relationship between these two forms of orienting and social functioning, cognition and the severity of ASD-related symptomatology in individuals with ASD needs to be examined.

## CHAPTER 5: ORIENTING ATTENTION, SOCIAL FUNCTIONING AND SEVERITY OF ASD SYMPTOMATOLOGY

### 5.1 Chapter Overview

This chapter examines the relationship between social and non-social orienting behaviours and ASD-related symptomatology, highlighting how deficits in orienting attention may relate to impairments in social behaviour and cognition. Gaps in the current research are highlighted, and methodological issues are overviewed.

### 5.2 Introduction

Atypicalities in visual perception and orienting are well documented in individuals with ASD (Dakin & Frith, 2005). A number of researchers have proposed that orienting deficits are observed for all stimuli (Courchesne et al., 1994; Elsabbagh et al., 2009; Kawakubo et al., 2004; Landry & Bryson, 2004; Townsend et al., 1999; Zwaigenbaum et al., 2005), while others postulate that orienting deficits are particularly more pronounced for social stimuli such as faces (Bird et al., 2006; Dawson et al., 1998; 2004; Klin et al., 2002; Leekam et al., 2000; Maestro et al., 2005; Speer et al., 2007; Swettenham et al., 1998). Developmental accounts propose that deficits disengaging, shifting and reorienting attention are present in the first year of life (e.g., Bryson, Landry et al., 2004; Elsabbagh et al., 2009; Zwaigenbaum et al., 2005). As these deficits precede later developing impairments in JA, play skills, social behaviour, and social cognition, it is possible that early difficulties disengaging, shifting and orienting attention, play a central role in the subsequent development of the more complex social impairments that are characteristic of ASD (Elsabbagh et al., 2009; Zwaigenbaum et al., 2005).

To determine the exact nature of orienting deficits in ASD, and to understand how impairments in orienting to social and non-social stimuli contribute to the development of ASD-



related symptomatology, the relationships between these two forms of orienting and later developing social, cognitive, and behavioural impairments need to be established. To date, few studies have examined this issue.

### 5.3 Disengaging and Shifting Attention and ASD Symptomatology

Human interactions and experiences are characterized by a constant, rapid, changing, and unpredictable flow of social, emotional, and situational information. The ability to rapidly select information for processing, and shift attention effortlessly across multiple sources of stimuli are critical for understanding, integrating and forming a complete representation of the situation or event.

A number of researchers have proposed that ASD is characterized by impairments disengaging and shifting attention rapidly between stimuli (Bryson, Landry et al., 2004; Courchesne et al., 1994; Elsabbagh et al., 2009; Kawakubo et al., 2007; Landry & Bryson, 2004; Zwaigenbaum et al., 2005). They have further proposed that early-occurring impairments in orienting attention may play a role in the social-communicative and behavioural abnormalities observed in individuals with ASD (Bryson, Landry et al., 2004; Courchesne et al., 1994; Landry & Bryson, 2004; Zwaigenbaum et al., 2005). While the developmental processes that precede the behavioural markers of ASD remain poorly understood, it is possible that difficulties disengaging and shifting attention may result in the failure to perceive and attend to pertinent information in the environment. This, in turn, may lead to the formation of a fragmented and incomplete comprehension of experiences and events (Courchesne et al., 1994). The developing infant's ability to conceptualise relationships between information and events, and benefit from predictive information or patterns may be compromised, hindering their social and emotional development (Courchesne et al., 1994; Townsend et al., 1996). An impaired ability to disengage and shift attention may also result in a preference for restricted, repetitive and highly predictable

experiences, and a propensity for disorganized and erratic emotional reactions when faced with unpredictable or novel experiences and interactions. Impairments in both reciprocal social interactions, and the preference for highly predictable experiences as opposed to novel exploration of the environment are highly characteristic of ASD (APA, 2000; Courchesne et al., 1994).

Few studies have examined the relationship between disengaging and shifting attention and the social behaviour of individuals with ASD. Despite this, a number of researchers have postulated that deficits orienting attention may be linked to impairments in social-communicative development (Zwaigenbaum et al., 2005), emotional regulation (Compton, Wirtz, Pajoumand, Claus, & Heller, 2004; McConnell & Bryson, 2005), JA, (e.g., Dawson et al., 2004; Leekam & Moore, 2001), and a local versus global processing style (Elsabbagh et al., 2009). In early studies, Casey et al. (1993) reported that an impaired ability to disengage and shift attention was related to an increased prevalence of savant skills, while Berger et al. (1993) reported that the ability to shift cognitive 'sets' predicted the level of social understanding in participants with ASD. More recently, Kawakubo et al. (2007) found that levels of presaccadic positivity (a physiological index of impaired disengagement) for adults with ASD relative to DD and neurotypical adults, were significantly correlated with the severity of impairment in imitation and sensory responsiveness as measured by the CARS. Kawakubo et al. (2007) tentatively concluded that impaired disengagement may contribute to deficits in observing others, and a preoccupation with non-social stimuli in individuals with ASD (refer to Chapter 3, Section 3.7.5 for a full description of this study). Additionally, Zwaigenbaum et al. (2005) proposed that impairments disengaging attention at 12 months of age were predictive of later social-communicative impairments at 24 months of age in high-risk infant siblings of children with ASD (refer to Chapter 3, Section 3.7.5 for a full description of this study).

Other researchers have proposed that a relationship exists between visual spatial attention, and the regulation of emotional states (Compton et al., 2004; McConnell & Bryson, 2005). Since the ability to disengage and distract attention from a source of upset is an important mechanism for

the regulation of emotional states (Compton et al., 2004; McConnell & Bryson, 2005), it has been hypothesised that an impaired ability to disengage and shift attention may result in difficulties regulating emotional responses to distressing experiences or interactions. While this issue has been under-examined in individuals with ASD, support for this notion has been found in studies of TD infants and children. For example, McConnell and Bryson (2005) examined the relationship between orienting attention and temperament in 25 TD infants. Participants were assessed longitudinally at 2, 4 and 6 months of age. In this study, infants participated in a computerized visual orienting task in which the latency to initiate a saccade following the onset of a peripheral stimulus was measured. The critical manipulation was whether the central stimulus remained (disengage trials) or was removed (shift trials) prior to the onset of the peripheral stimulus. Temperament was assessed using the Infant Behavior Questionnaire (IBQ; Rothbart, 1981). Results indicated that infants who shifted their attention most rapidly, showed lower fear responses to novel or unexpected stimuli at 4 months of age, and higher levels of smiling and fewer distress behaviours at 6 months of age. McConnell and Bryson (2005) concluded that the ability to disengage attention rapidly is critical for the development of emotional self-regulation.

Finally, Elsabbagh et al. (2009) proposed that an impaired ability to disengage attention may relate to the local information processing bias that is reported in individuals with ASD. Previous research suggests that TD individuals process information globally, which is more rapid and efficient than processing information at a local level. Evidence also suggests that global stimulus processing may depend on the ability to rapidly disengage, and move the focus of attention from one location to another (Frick, Colombo, & Saxon, 1999). Conversely, a tendency to focus on the local elements or features of the stimuli is associated with more prolonged looking (Frick et al., 1999). Thus, while the direction of causality remains unclear, it is possible that a bias for local versus global processing of stimuli in individuals with ASD may stem from impairments in orienting attention and, in particular, disengagement. Elsabbagh et al. (2009) proposed that the

tendency to focus for prolonged periods on local details of the stimulus would lead to difficulties integrating information and forming a complete and coherent representation of the stimulus or situation.

### *5.3.1 Summary of Research Examining Disengaging and Shifting Attention and ASD*

#### *Symptomatology*

In summary, a number of researchers have suggested that a relationship exists between impairments disengaging and shifting attention, and ASD-related symptomatology. In particular, difficulties rapidly disengaging and shifting attention have been related to impairments in social-communicative development (Zwaigenbaum et al., 2005) and emotional regulation (Compton et al., 2004; McConnell & Bryson, 2005). Impaired attentional orienting may also underlie the restricted temperamental styles observed in individuals with ASD, and the tendency to process information at a local versus global level (Elsabbagh et al., 2009). While not directly measured, it is also possible that an impaired ability to orient and attend to the ever-changing stimuli in the environment reduces socially relevant input at a time when social experiences provide the developing brain with critical input (Johnson, 2001; Kawakubo et al., 2007). This may disrupt the bias for social stimuli observed in TD infants and children, and contribute to the development of ASD-related symptomatology. Taken together, this research provides some support for the notion that early-occurring impairments in orienting attention may derail critical aspects of cognitive and social development, and lead to the impairments associated with ASD.

### *5.3.2 Limitations of Research Examining Disengaging and Shifting Attention and ASD*

#### *Symptomatology*

The exact role that deficits disengaging and shifting attention play in the development of ASD-related symptomatology, nevertheless, remains unclear. This issue remains largely understudied, and the ability to make comparisons and draw conclusions from the available research is hampered by the use of different samples and methodologies. Many of the postulated links between orienting and ASD-related symptomatology are theoretical rather than empirically established (Elsabbagh et

al., 2009), and many empirical investigations have used populations of TD infants and children (Compton et al., 2004; McConnell & Bryson, 2005). Furthermore, few aspects of ASD symptomatology have been examined in relation to impairments in disengaging and shifting attention, and no studies have directly examined the relationship between non-social orienting and social behaviour and social cognition in individuals with ASD. Finally, difficulties disengaging and shifting attention occur in other developmental disorders with markedly different social and cognitive profiles from ASD (e.g., Williams Syndrome; Brown et al., 2003; Cornish et al., 2007; Riby & Hancock, 2008; 2009a; 2009b; Scerif et al., 2004). Thus, the extent to which impaired disengagement and shifting attention alone can account for ASD-related symptomatology is questionable. Additional factors should therefore be considered (Elsabbagh et al., 2009).

#### 5.4 Social Orienting and ASD Symptomatology

A number of researchers have proposed that a specific impairment orienting attention to social stimuli leads to the social, behavioural and cognitive impairments observed in individuals with ASD (Dawson, Carver et al., 2005; Johnson et al., 2005; Schultz, 2005). Due to the social relevance of face processing and its fundamental importance to social development (Theeuwes & van der Stigchel, 2006), the ability to orient to faces has been a particular focus of these studies. The frequency of attention shifts to and between faces, and the duration of fixations to faces have been implicated. As these early-developing deficits precede impairments in JA, social cognition and pro-social behaviour and play skills, several researchers have proposed that the failure to orient to faces and other social stimuli, decreases socially relevant input which, in turn, leads to the development of the cognitive and social symptoms associated with ASD (Dawson, Webb, Wijsman et al., 2005; Johnson et al., 2005; Schultz, 2005). Infants with ASD fail to learn the significance of social cues and information, which impedes their ability to learn from social information presented in their environment (Leekam & Ramsden, 2006). According to this view, impaired social

orienting plays a central role in the social impairments observed in individuals with ASD. While the findings have been mixed, relationships between social orienting and JA (Dawson et al., 1998; 2004; Leekam & Ramsden, 2006), communication skills (Norbury et al., 2009), social competence (Klin et al., 2002), degree of social impairment (Jones et al., 2008; Klin et al., 2002) and social responsiveness (Speer et al., 2007) have been established.

#### *5.4.1 Social Orienting and JA*

Few studies have examined the relationship between social orienting and joint social attention in individuals with ASD. However, the results of studies by Dawson et al. (1998; 2004) and Leekam and Ramsden (2006) indicate that an impaired ability to orient attention to social stimuli and engage in dyadic social interactions impede the development of triadic social interactions in children with ASD.

Dawson et al. (1998; 2004) examined the relationship between social and non-social orienting and JA in two studies using 2- to 5-year-old children with ASD, DD, and TD children. In each study, participants were presented with a series of social and non-social stimuli. The time taken to orient to the stimuli was measured (refer to Chapter 4, Section 4.6.1 for full description of these studies). In the first study (Dawson et al., 1998), children's ability to follow JA bids (gaze and point cues) was examined using a simple shared attention task (Butterworth & Jarrett, 1991). In this task participants were seated at a table opposite an examiner. There was a toy on the table and four crosses mounted on the wall. To assess participants' ability to follow JA bids, the examiner gained the child's attention by placing the toy near her face. Once the child attended to the examiner's face, the toy was removed, and the examiner either pointed to, or looked at one of the four crosses on the wall. The average number of trials on which the participant failed to orient to the examiner's JA bid was calculated. In the second study (Dawson et al., 2004) children's ability to initiate and follow JA bids were assessed using relevant items from the Autism Diagnostic Observation Schedule- Generic (ADOS-G; Lord, Rutter, Goode, & Heemsbergen, 1989), and the ESCS (refer to Chapter 1, Section 1.10.1 for an explanation of this assessment).

The results of the studies by Dawson et al. (1998; 2004) indicated that the severity of JA impairment was strongly related to orienting to social stimuli for children with ASD (Dawson et al., 1998; 2004) and those with a DD (Dawson et al., 1998). No relationship was found between shared attention and orienting to non-social stimuli for these participants. For TD children, there was no relationship between JA and orienting to either social or non-social stimuli (Dawson et al., 1998). Dawson et al. (1998) concluded that an impaired ability to share attention in individuals with ASD may stem from a more basic impairment in orienting attention to social stimuli. They further concluded that the relationship between social orienting and social development in individuals with ASD may differ from those who are developing typically.

More recently, Leekam and Ramsden (2006) examined the association between dyadic social orienting and initiating and responding to JA bids. Nineteen children with ASD (Mean CA = 52.0 months) and 20 DD children (Mean CA = 53.6 months) participated in the study. Participants in each group were individually matched on cognitive ability. To assess dyadic social orienting, the mean percentage of incidental attention bids made by the examiner that were responded to by children was calculated. Two assessments were used to examine JA skills. In the first assessment, the child was seated at a table containing a series of toys. An examiner was seated on the floor behind the child. The child played with the toys for approximately five minutes, during which time their initiated JA bids (pointing and showing) were recorded. In the second assessment, several procedures to assess JA behaviours from the ESCS were implemented. These were, initiating joint attention (IJA), response to joint attention (RJA) and response to request (RR).

Results (Leekam & Ramsden, 2006) indicated that children with ASD responded to adult-initiated dyadic attention bids significantly less frequently than DD children. For children with ASD, responsivity to dyadic attention bids was significantly related to both verbal and nonverbal ability. A significant relationship between dyadic attention and IJA (pointing and showing) was also established for participants with ASD; however the relationship between dyadic attention and

RJA and was significant at .05 but not the pre-established .01 alpha level. Relationships between dyadic attention and JA, verbal and nonverbal ability were not observed for DD children. Leekam and Ramsden (2006) concluded that impairments in JA may be related to a more basic impairment in selectively attending to social stimuli for individuals with ASD.

#### *5.4.1.1 Summary of Research Examining Social Orienting and JA*

The results of these studies suggest that there is a relationship between social orienting, and initiating (Dawson et al., 2004; Leekam & Ramsden, 2006) and responding to JA bids for children with ASD (Dawson et al., 1998; 2004). The ability to engage in face-to-face interactions with others and selectively attend to social stimuli may provide the foundation for the development of later-emerging JA skills. Consequently, deficits attending to salient social stimuli early in life may underlie impairments in the development of JA. The relationship between orienting attention and JA was observed for social but not non-social stimuli for participants with ASD (Dawson et al., 1998). Furthermore, these relationships were not observed for TD children (Dawson et al., 1998). The relationship between social orienting and JA was less clear for DD participants, with a relationship observed between these variables in one study (Dawson et al., 1998), but not another (Leekam & Ramsden, 2006).

#### *5.4.1.2 Limitations of Research Examining Social Orienting and JA*

The social orienting assessments utilized in the literature (Dawson et al., 1998; 2004; Leekam & Ramsden, 2006), were limited to responses to auditory stimuli. Spontaneous orienting to visual or multiple (e.g., visual and auditory) sources of social stimuli were not examined. As a result, the relationship between spontaneous orienting to a variety of sources of social stimuli and the development of JA skills remains unclear.

Methodological limitations specific to Dawson et al. (1998; 2004) were discussed in Chapter 4, Section 4.6.4. These included the extent to which the stimuli used were good representations of naturally occurring social stimuli, and a failure to account for extraneous



variables (e.g., differences in participants' familiarity with social and non-social stimuli) that may have influenced the extent to which the stimuli captured the attention of participants. Dawson et al. (1998) additionally failed to address the role of social orienting in initiating JA bids, and did not examine the relationship between orienting attention and RJA in TD children.

In Leekam and Ramsden's (2006) study, the context in which the attention bid was delivered, and the differential impact this may have had on the responses of children with ASD and DD children were not accounted for. Specific factors that may have impacted on the likelihood that the child would respond to the attention bid included child's level of engagement to another stimulus or activity at the time of the attention bid (e.g., highly preferred verses less or non-preferred activity), the examiner's distance from the child when delivering bid, the volume, and tone of voice used to deliver the attention bid, and any additional prompting used to gain the child's attention. Accounting for these factors may have influenced the frequency with which children with ASD responded to the attention bid; helping to clarify the role of environmental and contextual factors in the social orienting impairment of children with ASD, and the relationship between dyadic orienting and other aspects of social and language development.

#### *5.4.2 Social Orienting and Social and Communication Skills*

Several studies have examined the relationship between orienting attention to faces and non-facial stimuli, and social behaviour in individuals with ASD. While the results of these studies are mixed, relationships between social orienting and communication skills (Norbury et al., 2009), social competence (Klin et al., 2002), degree of social impairment (Jones et al., 2008; Klin et al., 2002) and social responsiveness (Speer et al., 2007) have been established. Relationships between increased fixation times to non-facial sources of stimuli and reduced social functioning were also reported (Klin et al., 2002; Speer et al., 2007).

Klin et al. (2002) examined the relationship between social competence, social impairment, and visual fixation patterns to socially-rich movie clips in 15 high-functioning adolescents with

ASD (Mean CA = 15.4 years) and 15 TD adolescents (Mean CA = 17.9 years) (see Chapter 4, Section 4.6.2 for a description of reported group differences in visual fixation patterns). Social competence was assessed using the socialization domain of the Vineland Adaptive Behavior Scales, Expanded Edition (VABS-E; Sparrow et al., 1984) and social impairment was assessed using the social domain of the Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, DiLavore, & Risi, 1999). The results indicated that a higher percentage of time fixated on the mouth region was associated with higher ratings of social competence and lower levels of ASD-related social impairment. Conversely, a higher percentage of time fixated on objects was related to reduced social competence and higher levels of ASD-related social impairment. The relationship between fixation times to the body region and social competence revealed a similar trend as fixations to objects, however it failed to reach statistical significance. There was no relationship between the percentage of time fixated on the eye region and either measure of social competence. Klin et al. (2002) concluded that while orienting to faces is a key component of social interaction, individuals with ASD may gain more social advantage from orienting to the mouth than the eye region.

Similarly, Speer et al. (2007) examined the relationship between social behaviour, social responsiveness, and the duration of fixations to the eye and body regions of protagonists depicted in socially-rich movie clips. Twelve children and adolescents with ASD (Mean CA = 13.6 years) and 12 TD adolescents (Mean CA = 13.3) participated in this study (refer to Chapter 4, Section 4.6.2 for a description of reported group differences in visual fixation patterns). Social behaviour was assessed using the Autism Diagnostic Interview– Revised (ADI–R: Lord et al., 1994), the ADOS (Lord et al., 1999) and the Social Responsiveness Scale (SRS: Constantino & Gruber, 2005). Results showed that, for a combined group of participants with ASD and TD participants, those who spent more time fixated on the eye region were more socially responsive, while longer fixation times to the body region were related to reduced social responsiveness.

In a more recent study, Norbury et al. (2009) examined the relationship between visual fixation patterns and social functioning in 28 adolescents with ASD (Mean CA = 14.9 years) and 18 TD participants (Mean CA = 14.50 years). Groups were matched on CA and NVIQ. Participants with ASD were further classified as language impaired (ALI;  $n=14$ ) or non-language-impaired (ALN;  $n = 14$ ). In this study, participants were presented with five digitized colour-video clips depicting two to three characters engaged in familiar social interactions. While viewing the video clips, the percentage of time fixated on the eyes, mouths and bodies of the human actors, and other non-social elements of the scenes were recorded. Social competence was assessed using the social score from ADOS (Lord et al., 1999) and the social sub-scale of VABS-II (Sparrow, Cicchetti, & Balla, 2005). Communicative competence was assessed using the communication sub-scale of VABS-II (Sparrow et al., 2005). Results revealed that participants with ASD who spent a higher percentage of time fixated on the mouth region of the face obtained higher communicative competence scores. Conversely, participants with ASD who spent a higher percentage of time fixated on the eye region, obtained lower communicative competence scores. There were no relationships between the percentage of time fixated on the eye or mouth regions, and social competence as assessed by ADOS or the VABS-II. Norbury et al. (2009) concluded that attending to the mouth region of the face is important for the development of language and communicative competence in individuals with ASD.

Finally, Jones et al. (2008) examined the relationship between social impairment and visual fixation patterns in fifteen, 2-year-old children with ASD, 36 TD children and 15 DD children. Participants with ASD were matched with TD children on NVIQ and CA, and with DD children on VMA and CA. The mean CA of participants was 2.1 years. In this study, children were presented with a video depicting a human actress engaged in child-centred speech and social games (e.g., peek-a-boo). The percentage of time fixated on the objects, and the eye, mouth and body regions of the actress were recorded. Social impairment was assessed by the ADOS. Results indicated that children with ASD fixated on the eye region for a significantly lower percentage of time, and the

mouth region for a significantly higher percentage of time than TD and DD children. Results further showed that the percentage of time fixated to the eye region was related to social impairment; with participants with ASD who fixated on the eye region for the lowest percentage of time showing the greatest social impairment.

#### *5.4.2.1 Summary of Research Examining Social Orienting and Social and Communication Skills*

Studies examining the relationship between visual fixation patterns to faces and non-facial stimuli, and social functioning and symptomatology in individuals with ASD support the notion that the ability to orient attention to human faces plays an important role in the development of social and communication skills. The amount of time spent fixated on socially informative regions of the face may relate to the child's ability to understand and process social cues (Speer et al., 2007), and develop communicative competence. Attention to both the mouth and eye regions of the face have been implicated, however, the exact nature of the relationship between orienting attention to these regions of the face and social and communicative competence in ASD remains unclear.

A positive correlation has been established between the percentage of time fixated on the mouth region and social competence (i.e., interpersonal relationships; Klin et al., 2002) and communicative competence (i.e., receptive, expressive and written communication; Norbury et al., 2009) in children with ASD. Other researchers, however, have failed to establish a relationship between orienting to the mouth region of the face and level of social impairment (Jones et al., 2008; Norbury et al., 2009). Similarly, while a higher percentage of time fixated on the eye region was related to increased social responsiveness (Speer et al., 2007) and decreased social impairment (Jones et al., 2008), other researchers failed to establish a relationship between eye fixation times and social competence (Klin et al., 2002; Norbury et al., 2009) or degree of social impairment (Klin et al., 2002; Speer et al., 2009). In one study, increased fixation times to the eye region was related to reduced communicative competence in children with ASD (Norbury et al., 2002).

The inconsistent findings regarding the role of orienting to the eye or mouth regions of the face in the development of social and communicative competence, may reflect the different strategies used by participants with ASD to process and interpret facial stimuli. It has been widely documented that individuals with ASD are impaired in processing information and cues from the eye region of the face (Adolphis, Sears, & Piven, 2001; Baron-Cohen, 1995; Baron-Cohen, Wheelwright, Hill et al., 2001; Ristic et al., 2005; Senju, Yaguchi, Tojo, & Hasegawa, 2003). Eyes may be less meaningful or salient for these individuals, thereby reducing the extent to which this region is utilized as a source of social information. It is also possible that when individuals with ASD orient to the eye region, they are not able to extract social meaning from these cues to the same degree as non-autistic individuals. This is supported by a large body of research showing that individuals with ASD are impaired in their use of eye gaze cues to share attention and interpret the intentions and mental states of others (Adolphis et al., 2001; Baron-Cohen, 1995; Baron-Cohen, Wheelwright, Hill et al., 2001; Leekam et al., 2000; Ristic et al., 2005). Difficulties extracting socially relevant information from the eye region may be reflected in the negative relationship between eye gaze and communicative competence reported by Norbury et al. (2009).

Conversely, a number of researchers have proposed that increased fixation times to the mouth region may represent a compensatory strategy used by individuals with ASD to circumvent their poor understanding of eye cues, and to increase their social understanding (Klin et al., 2002; Norbury et al., 2009). It may be easier for individuals with ASD to construct meaning from literal speech than from other socially informative regions of the face, thereby increasing their attention to this area (Klin et al., 2002; Norbury et al., 2009). In particular, evidence suggests that orienting to the mouth region may play a central role in the development of communicative competence in these individuals (Norbury et al., 2009).

The results of these studies also provided some support for a relationship between longer fixation times to non-facial stimuli (e.g., objects and bodies) and higher levels of social impairment

for individuals with ASD. A higher percentage of time fixated on the body region was associated with decreased social responsiveness (Speer et al., 2007), while a higher percentage of time fixated on objects was related to increased social impairment and decreased social adaptation for participants with ASD (Klin et al., 2002). Klin et al. (2002) also reported that a higher percentage of time fixated on the body region was associated with a lower level of social adaptation and greater social impairment, however, this relationship failed to reach significance. In contrast, Speer et al. (2009) failed to find a significant relationship between the duration of fixations to the body region and scores on the ADI-R and ADOS.

While the results were mixed, these findings suggest that increased fixations to non-facial stimuli may be related to higher levels of social impairment. More time fixated on non-facial stimuli may reflect a reduced preference for, or salience of faces, subsequently leading to a decrease in socially-relevant input. Reduced socially relevant input may hinder the child's ability to understand, integrate, and form a complete representation of the social situation or event (Klin et al., 2002), subsequently impeding the social learning process.

#### *5.4.2.2 Limitations of Research Examining Social Orienting and Social and Communication Skills*

The extent to which the movie clips (Klin et al., 2002; Speer et al., 2007), and video footage (Jones et al., 2008; Norbury et al., 2009) utilized in these studies parallels the complexity of real-life social interactions is questionable. Social content (e.g., people and faces) were featured centrally and prominently, and non-relevant non-social stimuli (such as background objects) were reduced in a number of studies (Jones et al., 2008; Klin et al., 2002; Speer et al., 2007). This may have increased the likelihood of attending to social stimuli due to a lack of other, competing stimuli. Furthermore, only one of these studies featured direct gaze (Jones et al., 2008). The impact of specific stimulus attributes on orienting behaviour and the reported relationships between orienting and social behaviours in individuals with ASD warrants further investigation. Related to

this, the series of movie clips utilized by Klin et al. (2002) and Speer et al. (2007) were short segments extracted from an ongoing social interaction. Because the segments were presented out of context to the overall social interaction, it is possible that decreased attention to socially-relevant stimuli depicted in the clips reflected a decreased motivation of individuals with ASD to form a coherent understanding of the social situation presented, rather than atypical viewing patterns per se (Norbury et al., 2009). According to Norbury et al. (2009) the increased number of off screen fixations for individuals with ASD reported by Klin et al. (2002) may support this notion.

Studies examining the relationships between visual fixation patterns to faces and non-facial stimuli, and social functioning and symptomatology in individuals with ASD also failed to examine the relationships between social and non-social orienting and social and communicative competence in TD individuals (Klin et al., 2002; Norbury et al., 2009). The extent to which relationships between these variables for children with ASD parallel those in typical development is therefore unclear. Furthermore, Speer et al. (2007) examined the relationship between fixation times to the eye and mouth region and social responsiveness using a combined group of TD participants and those with ASD. It is unclear whether their findings reflected developmental patterns and associations for participants with ASD, TD participants, or both.

Finally, a number of studies used measures of parent report to assess social and communicative competence (Klin et al., 2002; Norbury et al., 2009; Speer et al., 2007). Studies based on parent report are limited by the effects of biases and inaccuracies regarding the severity of target behaviours (Zwaigenbaum et al., 2005). These studies are also limited by parents' knowledge of their child's diagnosis and their subsequent sensitivity to related developmental differences.

## 5.5 Chapter Summary and Conclusions

The current chapter summarized the literature examining the relationship between visual fixation patterns to faces and non-facial stimuli, and social functioning and symptomatology in

individuals with ASD. Overall the findings support the notion that early-emerging deficits in orienting attention contribute to the social-communicative and behavioural abnormalities associated with ASD. Deficits disengaging and shifting attention were related to impaired social-communicative development (Zwaigenbaum et al., 2005), emotional regulation (Compton et al., 2004; McConnell & Bryson, 2005), and a local versus global processing style (Elsabbagh et al., 2009); while an impaired ability to orient attention to faces and to other social stimuli were related to impairments in JA (Dawson et al., 1998; 2004; Leekam & Ramsden, 2006), social, and communicative competence (Jones et al., 2008; Klin et al., 2002; Norbury et al., 2009; Speer et al., 2007). Increased fixations to non-facial stimuli were also related to reduced social competence and responsiveness, and increased social impairments in participants with ASD (Klin et al., 2002; Speer et al., 2007). Taken together, these studies highlight the importance of shifting, disengaging and orienting attention to social stimuli in social-communicative and emotional development in ASD.



## CHAPTER 6: CURRENT RESEARCH

### 6.1 Chapter Overview

This chapter provides an overview of the rationale for the current research, highlighting gaps and methodological limitations with previous research. The present research is outlined, and the research hypotheses are presented.

### 6.2 The Current Research

The major aims of this research were to examine group differences in orienting attention to faces and non-facial stimuli, and the relationship between these forms of orienting and social functioning in high-functioning children with ASD and TD children.

Determining the exact nature of the orienting attention impairment in ASD, and the relationship between attention and social behaviour is important for a number of reasons. An impaired ability to orient attention likely manifests early in life and precedes other ASD-related symptomatology (Baranek, 1999; Clifford et al., 2007; Maestro et al., 2005; Osterling & Dawson, 1994; Osterling et al., 2002; Watson et al., 2007; Werner et al., 2000; 2005). Furthermore, while a general impairment in the ability to orient attention has been linked to the cerebellum and parietal lobe (Allen, Müller, & Courchesne, 2004; Belmonte & Yurgelun-Todd, 2003; Haist et al., 2005; Townsend et al., 2001), a specific impairment in orienting attention to social stimuli has been related to the amygdala (Dalton et al., 2005; Nacewicz et al., 2006; Schultz, 2005). Thus, understanding the nature of the orienting impairment in ASD will help to understand the neural basis and correlates of the disorder (Dawson et al., 2004). Understanding the earliest behavioural indicators of ASD will also aid in the development of diagnostic tools that can identify children with ASD at earlier ages; allowing for earlier identification and intervention, and the development of intervention programs that effectively target orienting attention abilities early in life.

## 6.3 Group Differences in Orienting Attention to Faces and Non-Facial Stimuli

### 6.3.1 *Rationale for Aims 1 and 2*

In Chapter 3, the literature pertaining to non-social orienting deficits in individuals with ASD was reviewed. The literature presented in this chapter supported the notion that individuals with ASD are impaired in rapidly disengaging and shifting attention across stimuli; particularly when required to make a voluntarily shift of attention (Courchesne et al., 1994; Elsabbagh et al., 2009; Kawakubo et al., 2004; Kemner et al., 1998; Landry & Bryson, 2004; Van der Geest et al., 2001; Zwaigenbaum et al., 2005). However, the ability to draw conclusions from these studies is hampered by fundamental differences in design and methodology, and methodological limitations. Studies examining shifting and disengagement in ASD have largely utilized computerized visual-cueing paradigms that lacked ecological validity. These studies assessed cued, rather than spontaneous orienting, and failed to compare social and non-social orienting within the same study (Courchesne et al., 1994; Elsabbagh et al., 2009; Kawakubo et al., 2004; Landry & Bryson, 2004; Van der Geest et al., 2001; Zwaigenbaum et al., 2005). No study has examined whether young children with ASD are impaired in their ability to make uncued attention shifts in a semi-naturalistic setting.

Chapter 4 examined social orienting in individuals with ASD. In the majority of these studies, the individuals' ability to orient attention to social and non-social stimuli was directly compared. Several researchers concluded that individuals with ASD demonstrated a specific impairment orienting attention to social stimuli (Baranek, 1999; Bird et al., 2006; Dawson et al., 1998; 2004; Klin et al., 2002; Maestro et al., 2005; Osterling & Dawson, 1994; Osterling et al., 2002; Riby & Hancock, 2009b; Speer et al., 2007; Swettenham et al., 1998). However, the presence or absence of a social orienting deficit appeared to be influenced by extraneous factors such as the degree of social complexity in the stimuli used (Klin et al., 2002; Norbury et al., 2009; Riby & Hancock, 2009a; Speer et al., 2007; Van der Geest et al., 2002).

The majority of studies examining social and non-social orienting in individuals with ASD assessed visual fixation patterns to stimuli presented on a computer screen in a controlled clinical setting (Fletcher-Watson et al., 2009; Klin et al., 2002; Newell et al., 2007; Riby & Hancock, 2008; 2009a; 2009b; Speer et al., 2007; Van der Geest et al., 2002). Static pictures and movie clips that may not capture the complexity of real-life social interactions were utilized as stimuli. Several studies also examined orienting responses to auditory stimuli presented in discrete trials (Dawson et al., 1998; 2004). Potentially distracting non-social stimuli were reduced in many of these studies (Jones et al., 2008; Klin et al., 2002; Speer et al., 2007), and possible differences in orienting to faces depicting direct or indirect eye gaze were not addressed (Fletcher-Watson et al., 2009; Klin et al., 2002; Riby & Hancock, 2008; 2009a; 2009b; Speer et al., 2007; Van der Geest et al., 2002). Finally, eye fixation patterns were examined within a context in which the child was an observer and not a participant in the social interaction (Fletcher-Watson et al., 2009; Klin et al., 2002; Riby & Hancock, 2008; 2009a; 2009b; Speer et al., 2007; Van der Geest et al., 2002). Since manifestations of ASD-related impairments are more pronounced in naturalistic than experimental settings (Klin et al., 2002), further research examining social and non-social orienting in more ecologically valid settings is warranted.

In the current research these limitations and gaps in previous research were addressed. Ecological validity was fostered by examining social and non-social orienting in both a semi-naturalistic and naturalistic setting. Visual orienting was specifically examined within the context of real-life interactions with others in which the child was a participant in, rather than an observer of the social interaction. Non-social stimuli were featured in each environment, and specific experimental cueing was eliminated. As with previous studies (Klin et al., 2002; Riby & Hancock, 2008; 2009a; 2009b; Speer et al., 2007), overt (i.e., observable) eye movements to and between social and non-social stimuli were examined. It has been well documented that measures of eye gaze provide real-time measures of visual and cognitive processing (Liversedge & Findlay, 2000). They reveal information about attention and attentional preferences (Henderson, 2003; Riby &

Hancock, 2009a; 2009b), and enable the identification of environmental stimuli that captures the child's attention (Norbury et al., 2009). Assessments of eye gaze are particularly useful for young children and those with developmental disabilities because they can be directly observed in the absence of instructions or cueing (Luna, Garver, Urban, Lazar, & Sweeney, 2004). While the majority of previous studies examining social and non-social orienting in individuals with ASD focused primarily on the percentage of overall time fixated on regions of interest (Klin et al., 2002; Riby & Hancock, 2008; 2009a; 2009b; Speer et al., 2007), the current research expanded the scope of orienting behaviours assessed to include the frequency of attention shifts between different categories of facial and non-facial stimuli, and the duration of fixations to stimuli.

### *6.3.2 Aim 1*

The first aim of this research was to examine attention to faces and non-facial stimuli in a semi-naturalistic setting for 3- to 6-year-old children with HFASD, compared to TD children matched on CA, gender, NVIQ, and expressive language. The procedures employed by Swettenham et al. (1998) were adopted. Participants were engaged in free play with toys in the presence of a parent and researcher for approximately five minutes, during which time their visual fixation patterns to specific regions of interest were assessed. Two specific aspects of orienting attention were examined. First, to establish whether children with ASD showed a general impairment orienting attention relative to TD children, their mean number of attention shifts per minute was calculated. Second, to examine whether children with ASD showed an atypical distribution of attention between faces and non-facial stimuli relative to TD children, the percentages of total viewing time fixated on faces, objects, bodies and unfocused were calculated. The frequency of attention shifts between faces, facial and non-facial stimuli (bodies and objects), and between non-facial stimuli; and the average duration of fixations to objects, eye, and body regions, were also examined.

It was predicted that group membership (specifically the presence or absence of ASD) would be associated with different visual fixation patterns. Based on the findings of previous

research, it was predicted that children with ASD would demonstrate impairments relative to TD children in orienting both to faces and to non-facial stimuli, however, the impairment would be more severe for orienting to faces.

With regards to a general impairment in orienting attention, it was hypothesized that children with ASD would show a general impairment in orienting attention as evidenced by a significantly lower mean number of attention shifts per minute relative to TD children. With regards to a specific impairment in orienting attention to faces, it was hypothesized that children with ASD would show an atypical distribution of attention between faces and non-facial stimuli, relative to TD children: (i) Children with ASD would fixate on people's faces for a significantly lower percentage of time, and non-facial stimuli (objects, bodies and unfocused) for a significantly higher percentage of time, than TD children; (ii) Children with ASD would make significantly fewer shifts of attention between faces (face ↔ face) and faces and non-facial stimuli (face ↔ objects, face ↔ body), and significantly more attention shifts between non-facial stimuli (object ↔ object, object ↔ body) per minute than TD children; and (iii) children with ASD would fixate on faces for significantly shorter mean durations, and to non-facial stimuli (object, bodies and unfocused) for significantly longer mean durations than TD children. The results for these hypotheses are presented in Chapter 8, Section 8.2.1.

### *6.3.3 Aim 2*

The second aim was to examine participants' attention to social stimuli (faces) in the naturalistic social setting by observing social orienting behaviour during a period of unstructured social interaction with peers in the preschool or school setting, and examining the proportion of observation intervals during which the child fixated on peers' faces.

It was hypothesized that children with ASD would demonstrate an impairment in social orienting, as evidenced by a lower mean percentage of fixations to peers' faces in the naturalistic setting, relative to a matched group of TD children. The results for these hypotheses are presented in Chapter 8, Section 8.2.2.

## 6.4 Social Functioning, Severity of ASD Symptomatology and Orienting Attention to Faces and Non-Facial Stimuli

Aims 3 to 6 were to examine the relationships between social functioning and the severity of ASD symptomatology, and orienting attention to faces and non-facial stimuli. The ability to establish and maintain social interactions with peers is a critical aspect of development, and impairments in the development of pro-social behaviour and cognition are recognised as core features of ASD (APA, 2000). As a result, a further aim of this research was to expand current knowledge regarding the role of attention in the development of social behaviour in individuals with ASD.

In Chapter 5, the literature examining the role of social and non-social orienting in the development of social behaviour was presented. This literature supported the notion that early-emerging impairments in orienting attention contribute to the social-communicative and behavioural abnormalities associated with ASD (Dawson et al., 1998; 2004; Elsabbagh et al., 2009; Jones et al., 2008; Klin et al., 2002; Leekam & Ramsden, 2006; Norbury et al., 2009; Speer et al., 2007; Zwaigenbaum et al., 2005). However, many of these findings were based on broad assessments of social behaviour based on parental report (Klin et al., 2002; Norbury et al., 2009; Speer et al., 2007), indirect assessments of social behaviours based on measures of autistic symptomatology, and observations of social responsiveness in a clinical setting (Jones et al., 2008; Klin et al., 2002; Norbury et al., 2009; Speer et al., 2007). The association between social and non-social orienting and pro-social behaviour and play skills with peers in a naturalistic setting has not been directly examined, nor have these relationships been examined in TD or DD comparison groups (Jones et al., 2008; Klin et al., 2002; Norbury et al., 2009; Speer et al., 2007). As a result, the exact role of social and non-social orienting in the development of social behaviour for children with ASD relative to TD and DD comparison groups warrants further investigation.

One aim of the current research was to address these issues by examining the relationship between social and non-social orienting, and social functioning and severity of ASD

symptomatology in children with ASD relative to TD children. Social functioning was operationalized as the child's social interactions and social understanding with TD peers in the natural social setting, and was comprised of four assessments: an observation of children's positive social behaviour and play skills with peers in the preschool or school setting, teacher ratings of social behaviour, and ToM understanding.

#### *6.4.2 Aim 3*

In Aim 3, the relationship between social functioning and two specific aspects of orienting attention were examined. These were general orienting ability, and the distribution of attention between faces and non-facial stimuli.

It was hypothesised that impairments in orienting attention, as measured by the distribution of attention between faces and non-facial stimuli in the semi-naturalistic setting, would be associated with deficits in social functioning, as measured by assessments of positive social behaviour, play skills, ToM and teacher ratings of social behaviour for participants with ASD. With regards to the relationship between social functioning and a general impairment orienting attention, it was hypothesised that there would be a positive correlation between social functioning and the mean frequency of attention shifts per minute, for both children with ASD and TD children. With regards to the relationship between social functioning and the distribution of attention between faces and non-facial stimuli, it was hypothesized that: (i) a higher percentage of time fixated on faces would be positively correlated with social functioning while a higher percentage of time fixated on non-facial stimuli (objects and bodies or unfocused) would be negatively correlated with social functioning for both participants with ASD and TD participants; (ii) a higher number of attention shifts per minute between faces (i.e., face ↔ face) and faces and non-facial stimuli (i.e., face ↔ object, face ↔ body) would be positively correlated with social functioning, while a higher number of attention shifts between categories of non-facial stimuli (object ↔ object, object ↔ body) would be negatively correlated with social functioning scores for participants with ASD and TD participants; and (iii) a higher mean duration of visual fixation to faces would be positively

correlated with social functioning while higher mean duration of visual fixation to non-facial stimuli (objects, bodies and unfocused) would be negatively correlated with social functioning for children with ASD and TD children. The results for these hypotheses are presented in Chapter 9, Section 9.2.1.

#### *6.4.3 Aim 4*

In Aim 4, the relationship between social functioning and participants' attention to social stimuli (faces) in the naturalistic social setting was examined. It was hypothesized that the percentage of visual fixations to peers' faces in the naturalistic setting would be positively correlated with social functioning for participants with ASD and TD children. The results for these hypotheses are presented in Chapter 9, Section 9.2.2.

#### *6.4.4 Aim 5*

In Aim 5, the relationships between the severity of ASD symptomatology and the ability to orient attention to faces and to non-facial stimuli were examined. It was hypothesised that impairments in orienting attention would be associated with higher levels of ASD symptomatology for participants with ASD. With regards to the relationship between the severity of ASD symptomatology and a general impairment orienting attention, it was hypothesised that there would be a negative correlation between the severity of ASD symptomatology and the mean frequency of attention shifts per minute. With regards to the relationship between the severity of ASD symptomatology and the distribution of attention between faces and non-facial stimuli, it was hypothesized that: (i) a higher percentage of time fixated on faces would be negatively correlated with the severity of ASD symptomatology while a higher percentage of time fixated on non-facial stimuli (objects and bodies or unfocused) would be positively correlated with the severity of ASD symptomatology; (ii) a higher number of attention shifts per minute between faces (i.e., face ↔ face) and faces and non-facial stimuli (i.e., face ↔ object, face ↔ body) would be negatively correlated with the severity of ASD symptomatology, while a higher number of attention shifts between categories of non-facial stimuli (object ↔ object, object ↔ body) would be positively



correlated with the severity of ASD symptomatology; and (iii) a higher mean duration of visual fixation to faces would be negatively correlated with the severity of ASD symptomatology, while higher mean duration of visual fixation to non-facial stimuli (objects, bodies and unfocused) would be positively correlated with the severity of ASD symptomatology. The results for these hypotheses are presented in Chapter 9, Section 9.3.1.

#### *6.4.5 Aim 6*

In Aim 6, the relationship between the severity of ASD symptomatology and participants' attention to social stimuli (faces) in the naturalistic social setting was examined. It was hypothesized that the percentage of visual fixations to peers' faces in the naturalistic setting would be negatively correlated with the severity of ASD symptomatology for children with ASD. The results for this hypothesis is presented in Chapter 9, Section 9.3.2.

### 6.5 Chapter Summary

The current chapter presented the rationale for the current research, highlighting gaps and methodological limitations with previous research. The aims of this research were to examine whether children with ASD differed from TD children in the time they spent looking at faces verses non-facial stimuli in the semi-naturalistic and naturalistic settings. In the semi-naturalistic setting, specific group differences in the frequency of attention shifts to and between faces and non-facial stimuli, and the duration of visual fixations to faces and non-facial stimuli (percentage of overall time and average duration of fixations) were examined. Other aims of this research were to examine whether specific visual fixation patterns to faces and non-facial stimuli were related to social functioning for children with ASD and TD children. Relationships between attention to faces in the naturalistic setting and social functioning were also examined for both groups of children. A final aim of the current research was to examine whether relationships existed between the severity of ASD symptomatology and attention to faces and non-facial stimuli and for children with ASD in both the semi-naturalistic and naturalistic settings.

## CHAPTER 7: RESEARCH DESIGN

### 7.1 Chapter Overview

This chapter describes the criteria for participation in this research and the general methodology. Diagnostic, language, cognitive, attention and social assessments are described, and the general procedures utilized in this research are outlined. Finally, group matching, scoring and data analysis procedures are described.

### 7.2 Participants

Two groups participated in the current research: high-functioning children with an Autism Spectrum Disorder (HFASD) and typically developing (TD) children. The parents of 25 children with a reported DSM-IV-TR (APA, 2000) or DSM-IV (Diagnostic and Statistical Manual of Mental Disorders, 4<sup>th</sup> ed.; APA, 1994) diagnosis of Autistic Disorder (AD) or Asperger's Disorder (AsD) responded to advertisements by contacting the researcher for further information regarding the current research. The parents of three (male) children who were provided with research information declined to participate. Parents of twenty-two children agreed to their child's participation. A further two participants (1 male and 1 female) were unable to complete the required assessments due to practical difficulties, and were subsequently excluded from analyses. The final sample was thus comprised of 20 children (17 males and 3 females). Nineteen participants were diagnosed with AD and one participant was diagnosed with AsD. These participants will be referred to as the ASD group herein.

All participants diagnosed with AD or AsD were diagnosed by experienced psychologists from their local Regional Centre, or a private psychologist specializing in ASDs. All diagnostic reports and clinical records pertaining to participants' developmental histories were viewed to confirm diagnosis. Children who received their diagnosis from the Regional Centre typically undertook a multi-disciplinary assessment, which included speech and language assessments from a registered Speech Pathologist. When assessments were conducted by a private psychologist, paediatric and speech pathology reports were reviewed prior to

diagnosis. DSM-IV-TR (APA, 2000) or DSM-IV (APA, 1994) diagnostic criteria were utilized by all psychologists.

At the time the participants were diagnosed, the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2002), and the Autism Diagnostic Interview-Revised (ADI-R; Lord et al., 1994) were not commonly utilized as part of the assessment protocol. However, all children received a battery of standardized and non-standardized assessments including cognitive (e.g., Bayley Scales for Infant Development - Second Edition; BSID-II; Bayley, 1993), adaptive behaviour (e.g., Vineland Adaptive Behaviour Scale; VABS; Sparrow et al., 1984) and diagnostic (e.g., Childhood Autism Rating Scale (CARS; Schopler, Reichler, & Renner, 1988); Gilliam Autism Rating Scale (GARS; Gilliam, 1995), assessments. Clinical interviews with parents, and play and behaviour observations also formed a critical part of the assessment protocol. Six children were additionally given the ADOS, the ADI-R, or both. In three instances, children were also observed in their home or school setting. The Social Communication Questionnaire (SCQ; Rutter et al., 2003) was also administered to verify diagnosis. This is consistent with previous research (Norbury et al., 2009).

Children in the ASD group met the following criteria: age 3 to 6 years ( $M = 60.45$  months,  $SD = 13.29$ , range = 40 to 79 months), absence of an ID, a clinical diagnosis of AD or AsD. A number of studies have demonstrated that individuals with AD and AsD do not differ in their visuo-spatial orienting abilities (Renner et al., 2006; Verté et al., 2006), and have been included together in previous research (Fletcher-Watson et al., 2009; Landry et al., 2009; Renner et al., 2006): None of the children had known visual impairments or wore eye glasses. Finally, all of the participants with ASD participated in early intervention programs based on the principles of Applied Behaviour Analysis (ABA) and additionally attended mainstream preschools, kindergartens or elementary schools in Los Angeles, USA.

The parents of 26 TD children contacted the researcher for further information regarding the current research. The parents of 6 children (5 male; 1 female) who were provided with research information declined to participate. Twenty children were recruited for participation. As one participant was unable to complete the required assessments due to

scheduling difficulties, the participant was excluded from analyses. The final sample was thus comprised of 19 TD children (16 males; 3 females). At the time of recruitment, parents confirmed that their children had no history of learning delays, language delays, ASDs or other developmental disorders, or siblings with an ASD. None of the TD children had known visual impairments or wore eye glasses. The SCQ was administered to confirm the absence of an ASD. TD participants were aged from 3 to 6 years, with a mean age of 56.37 months ( $SD = 13.99$ , range 37 to 78 months). All TD children attended mainstream preschools, kindergartens or elementary schools in Los Angeles, USA.

### 7.3 Materials and Task Procedures

#### 7.3.1 *Social Communication Questionnaire (SCQ) - Lifetime Form*

To confirm participants' diagnosis of an ASD, the SCQ (Rutter, Bailey et al., 2003) was used. The SCQ is a 40-item screening measure that taps into the behavioural symptoms associated with ASD. The SCQ was originally designed as a companion to the ADI-R (Rutter, Le Couteur et al., 2003), and is comprised of items that match the ADI-R items with the highest discriminative diagnostic validity. Correlations calculated between the ADI and SCQ for total score and ADI domain totals were found to be statistically significant. The SCQ has been designed for use in all age groups, 4 years of age and over, however, it can be used in younger children provided the child's mental age exceeds 2 years of age (Rutter, Bailey et al., 2003). Results from the SCQ provide a measure of ASD symptomatology, with a cut-off score indicating the likelihood the individual has an ASD. The internal consistency of this scale ranges from .81 to .92. Due to the recent findings that some children with ASD score below the current cut-off score of 15 (Goin-Kochneil & Cohen, 2008), and that a cut-off score of 11 increases sensitivity without jeopardizing specificity (Corsello et al., 2007; Wiggins, Bakeman, Adamson, & Robins, 2007), children with a clinical diagnosis of ASD who obtained an SCQ score of 11 or more, were included for participation in the current research. TD children with this score range were excluded.

### *7.3.2 Leiter International Performance Scale – Revised (Leiter-R)*

Participants' non-verbal IQ was assessed using the Leiter-R (fast screening; Roid & Miller, 1997). The figure ground, form completion, sequential order, and repeated patterns sub-tests were administered. Together, these sub-tests provided a reliable estimate of global intellectual level in addition to measures of fluid reasoning ability (deductive reasoning) and visual/spatial ability. This test has a reliability score of .90 for 1 to 10-year-olds and .89 for 11 to 20-year-olds (Roid & Miller, 1997). The Brief IQ scale of the Leiter-R has a reported correlation of .85 with the performance scale of the Wechsler Intelligence Scale for Children – 3rd edition (WISC-III; Wechsler, 1991).

The Leiter-R fast screening was administered to all participants, with the exception of three participants with ASD who had completed the Leiter-R with a registered psychologist within 12 months of participation in the current research. For these participants, a full report containing all scores was supplied to the researcher by parents. The full-scale IQ of the Leiter-R was used.

### *7.3.3 Preschool Language Scale – 4<sup>th</sup> edition (PLS-4)*

Participants' Auditory Comprehension skills (ability to understand language) and Expressive Communication (spoken language) were assessed using the PLS-4 (Zimmerman, Steiner, & Pond, 2002). The PLS-4 is an individually administered test for measuring the language skills of children from birth through 6 years, 11 months. The test-retest stability coefficient of this assessment ranges between .82 and .95 for the subscale scores, and .90 to .97 for the Total Language Score. The internal consistency reliability coefficients range from .66 to .96.

The PLS-4 was administered to all participants, with the exception of three participants with ASD who had completed the PLS-4 with a registered Speech and Language Pathologist (SLP) within 6 months of participation in the current research. For these participants, a full report containing all scores was supplied to the researcher by parents.

#### *7.3.4 Social and Non-Social Orienting in the Semi-Naturalistic Setting*

The social orienting task used in this research was adapted from the study by Swettenham et al. (1998). In this task, five toys were laid out on the floor of an otherwise empty room in a Center for Autism and Related Disorders (CARD) office location in greater Los Angeles, or in a quiet room in their home, cleared of all toys and objects. This is consistent with the methodology employed by Swettenham et al. (1998).

Toys included a slinky, barrel of linking monkeys, police (toy) walky talky, small magnadoodle© drawing board, and a talking soft toy (donkey). Participants were taken to the pre-prepared room and told “You can play with the toys if you want to.” One parent and the researcher were present during the session, and sat either side of the toys on opposite sides of the room. They did not interact with the child unless the interaction was initiated by the child. If the parent or researcher responded to the child, interaction episodes were kept as brief as possible. Participants were video recorded for approximately 5 to 7 minutes while engaging in free play with the toys.

Overt eye movements were analysed from the video footage (Swettenham et al., 1998). Video footage was analysed in slow motion, frame by frame, using Adobe Premier Pro 1.0 video editing software application (Adobe, 2003). Each frame represented 33 milliseconds. Video footage was analysed from the first frame in which the child’s eyes were clearly visible to prevent selection bias. Five minutes of video footage were scored for all participants.

In the study by Swettenham et al. (1998), visual fixations to people, objects, or unfocused were coded. To improve the specificity of the coding criteria in the current study, a number of additional scoring categories were created. Visual fixations to ‘people’ were re-classified according to whether the child was looking at the person’s face or their body. The ‘unfocused’ category utilized by Swettenham et al. (1998) was divided into three separate categories: ‘unfocused’, ‘moving’ and ‘not fixated / engaged.’ Specific rules for scoring were created for each category to increase reliability.

The resulting scoring criteria were: (1) Looking at an object. This was scored if the child’s eyes were clearly fixated on one of the five toys or any other object in the room. for

more than 100ms (Van der Geest et al., 2002). (2) Looking at a face. This was scored if the child's eyes were clearly fixated on a person's face for more than 100ms (Van der Geest et al., 2002). (3) Looking at a body. This was scored if the child's eyes were clearly fixated on any part of a person except his / her face, head or hair for more than 100ms (Van der Geest et al., 2002). (4) Moving. This was scored if the child's eyes were not focused on an object, person, or body, and there were observable head and / or eye movements. Several frames before and after the 'moving' classification were examined at a slightly faster speed to confirm that the child's eyes were moving from one fixation point to another. (5) Not fixated / engaged. This was scored if there was an absence of a fixation to a face, body or object within the context of an ongoing activity, and there was a simultaneous behaviour that showed the child was still engaged in the initial activity (such as writing on the magnadoodle©, looking up and saying "Um" for a few seconds before returning to write on the magnadoodle©). This classification further required that there were no observable eye or head movements. (6) 'Unfocused'. This was scored if the child's eyes were not fixated on a face, body or object, and there were no observable eye or head movements. For this classification, the unfocused behaviour did not occur within the context of an ongoing activity, nor did the child show any indication of being engaged in an activity. For each classification, several frames both preceding and following the observed behaviour were examined at a slightly faster speed to confirm the classification.

Consistent with Swettenham et al. (1998), each category of behaviour (above) was recorded sequentially. From the resulting data, Swettehmam et al. (1998) calculated the frequency of attention shifts between objects, people and objects and people. The percentage of time spent looking at objects, people or unfocused, and the average duration of fixations within each category were also calculated. Due to the scoring adaptations made in the current study, additional categories were created. Consequently, the following scores were calculated: (a) The mean number of overall attention shifts per minute (total shifts to objects, faces, and bodies); (b) The mean number of attention shifts per minute between faces (face ↔ face), faces and non-facial stimuli (face ↔ object, face ↔ body), and non-facial stimuli (object ↔ object, object ↔ body, body ↔ body); (c) The percentage of overall time fixated on faces, objects,

bodies or unfocused; (d) The average duration of fixations to faces, objects, bodies or unfocused; (e) Attention shifts were not counted if a period of ‘unfocused’ or not fixated / engaged separated the fixations. They were therefore only classified as shifts of attention if separated by a ‘moving’ classification. The percentage and duration of time not fixated / engaged and moving were not used in the analyses due to their lack of theoretical relationship with the variables of interest in this investigation.

Data were not taken on the portions of the video where the parent was directing the child’s attention or where the child’s eyes and face were not clearly visible on the video footage. These periods of time were classified as ‘no data’ in the resulting data file. An analyses of the number of periods where no data were available for participants with ASD ( $M = 1.40$ ,  $SD = 1.73$ ) and TD participants ( $M = 1.05$ ,  $SD = 1.22$ ) found no differences in the number of unavailable data periods between the groups  $t(37) = .72$ ,  $p = .48$ .

The student researcher and a second scorer, blind to the aims of the research and the diagnosis of participants, trained in the scoring procedures associated with the video footage until mean inter-observer agreement was of .80 was obtained. Training was accomplished via a review of the coding procedures followed by viewing and scoring video samples of children not associated with the current research. All video tapes were then scored by the researcher in the current investigation. Twenty-five percent of videos were randomly selected and scored by the second scorer. Inter-observer agreement was calculated using Intraclass Correlation Coefficient (ICC; Portney & Watkins, 2000; Shrout & Fleiss, 1979). Moderate to very high levels of inter-observer agreement were obtained for all variables (Portney & Watkins, 2000). ICC’s ranged from .69 to .98. The mean inter-observer agreement was .88. Refer to Appendix B, Table B1, for the ICC’s for all attention variables. All data reported are from the student researcher associated with this research.

### *7.3.5. Observation of Social Orienting, Positive Social Behaviour and Play Skills in the Naturalistic Setting*

To assess social orienting, positive social behaviour and play skills in the naturalistic social setting, participants were observed interacting with peers in the preschool or school



setting for one 20 to 30 minute period. Observations took place during recess and unstructured play time, in either the classroom or outdoors. Data were not taken during snack or lunch periods due to varying levels of structure and subsequent variation in the opportunities for social interaction during these periods. There was no significant difference in the duration of the observations for TD participants,  $M = 25.95$ ,  $SD = 4.50$  and those with ASD,  $M = 25.15$ ,  $SD = 6.18$ ;  $t(34.71) = -.46$ ,  $p = .65$ . For each observation period, a single child's social behaviour was recorded using an interval recording system. The observer watched the child's behaviours for 50-seconds and then recorded their observations for approximately 10-seconds. A stopwatch was utilized to ensure that all observation intervals were exactly 50-seconds. The observer maintained close proximity to the child, however, did not interact with him / her. Any overtures made by the child were politely rejected. Children were told that the observer was interested in learning about their play behaviours. Due to the emphasis on the child's spontaneous social behaviour with peers, only peer-based social behaviours were recorded. Classroom teachers and / or classroom integration aides were politely asked not to direct the child's play and / or intervene in the child's behaviour unless necessary for the duration of the observation period. Section 7.3.5.1 describes the specific data collection procedures pertaining to social orienting in the naturalistic setting; section 7.3.5.2 describes the data collection procedures pertaining to positive social behaviour; and section 7.3.5.3 describes the data collection procedures pertaining to play skills.

The researcher and a second scorer, blind to the aims of the research and the diagnosis of participants, were trained in scoring social orienting, positive social behaviour and play skills until an inter-observer agreement of .80 was achieved. The second scorer for this assessment differed from the second scorer used for the aforementioned video analysis, and was not involved in any other aspects of the study. Training was accomplished through a review of the scoring procedures followed by viewing and scoring video samples of children engaged in social interaction with peers who were not associated with the current research. All social observations were then undertaken by the student researcher associated with the current research. The second scorer attended and scored 25% of the social observations. Half of the

observations were for children with ASD and half of the observations were for TD children. Inter-observer agreement was calculated using ICC (Portney & Watkins, 2000; Shrout & Fleiss, 1979). Moderate to very high levels of inter-observer agreement were obtained for all variables (Portney & Watkins, 2000). An ICC of .89 was obtained for social orienting in the naturalistic setting. For positive social behaviour scores, ICC's ranged from 0.65 to 0.96, with a mean ICC of 0.82. It was not possible to obtain ICC's for three positive social behaviour variables: initiates help (self), responds an offer of help (for self), and responds to a request to help another, as these behaviours were not demonstrated by participants in the current study. Refer to Appendix B, Table B2 for the ICC's for all positive social behaviour variables. Finally, the ICC's for play scores ranged from 0.70 to 0.96, with a mean ICC of .87. Refer to Appendix B, Table B3 for the ICC's for all play variables. All data reported in this research are from the researcher associated with this research.

#### *7.3.5.1 Social Orienting in the Naturalistic Setting*

To examine social orienting in the naturalistic setting, the presence or absence of a visual fixation to a peers' face was recorded for each observation interval. The percentage of observation intervals the child made visual fixations to peers faces was calculated for each participant.

#### *7.3.5.2 Positive Social Behaviour*

To assess children's positive social behaviour, target behaviours were classified as being absent or present for each observation interval. A coding scale based on Huack et al.'s (1995) Behaviour Coding Scheme for children with autism was adapted from Bauminger (2002). This scheme was designed for observations in the child's natural school environment, and it coded social initiations and responses in three main behavioural categories: positive social interaction, negative social interaction, and low-level social interaction. For the purposes of the current investigation, the coding scheme for positive social interactions was utilized. These scores were deemed most appropriate for the examination of the relationship between

positive social behaviour and social and non-social attentional orienting. In this coding scheme positive social behaviours were comprised of verbal and non-verbal social behaviours that lead to a successful social interaction with peers. These behaviours served to start or maintain a social interaction.

The majority of recorded behaviours were defined as being either social initiations or social responses. Social initiations were behaviours used by the child to begin a new sequence of social interaction. They were differentiated from the previous sequence by a change in the peer(s) or activity, or the discontinuation of the previous sequence for a minimum of 5 seconds (Huack et al., 1995). Social responses were defined as the child's verbal or non-verbal responses to social behaviour directed towards him / her by his / her peers (Bauminger, 2002; Huack et al., 1995). The child could initiate social interaction or respond to social interactions initiated by his / her peers using several different behaviours within one observation interval.

A number of modifications from the scoring scheme presented by Bauminger et al. (2002) were made to improve the consistency of scoring and ensure that all of the categories of social behaviours were clearly defined and mutually exclusive. First, smiling behaviours were not recorded in terms of responses or initiations due to difficulties obtaining accurate and reliable recordings of these behaviours in 'real' time. Instead, smiling behaviours were recorded in each interval as either being present or absent. In addition, 'sharing of objects and experiences' were separated into two independent classifications; 'social communication' was removed due to its overlap with other behavioural categories (such as the use of sharing objects and experiences to initiate social interactions); the 'initiating play' classification from Huack et al.'s (1995) original coding scheme was reintroduced; and the 'offers or gets help' classification was separated into two categories to reflect whether the child requested or received help or information for him/herself or whether the child offered, or responded to a request for help or information from another child.

The target behaviours that were thus recorded in the current research were social smiling (with and without eye-contact), affection, sharing of objects and experiences (about self), expressing interest in a peer, requesting or accepting help for one's self, offering or

responding to request for help from a peer, making a direct play request, and initiating or responding to greetings. Refer to Appendix C for a detailed description of the positive social behaviour scoring procedures.

Following the observation for each participant, a total positive behaviour score was obtained. This score was determined by calculating the total number of positive social behaviours observed across the number of observation intervals. A percentage was then obtained. Percentages were calculated in the same way for each of the individual behaviours that comprised the positive social behaviour score.

#### *7.3.5.3 Play Skills*

To assess participants' play skills in the naturalistic setting, the Parten Scale, adapted by Ballard (1981), was utilized. This play scale has been used in recent studies of children with ASD (Anderson et al., 2004), and classifies play behaviours into six distinct categories: unoccupied, solitary, independent, onlooker, parallel, associative, or cooperative / organized play. For each 50-second observation interval, the child's dominant type of play was recorded. The play categories were mutually exclusive, and only one type of play could be recorded in each interval. Each category of play was then assigned a score from 0 (unoccupied) to 5 (cooperative / organized). Consistent with Anderson et al. (2004), the total play score was calculated by assigning a play score (0 = unoccupied; 1 = solitary; 2 = onlooker; 3 = parallel; 4 = associative; 5 = cooperative) for each interval and summing the scores. The total score was then divided by the number of observation intervals to obtain a mean play score per interval. For further analysis, the percentage of intervals in which the child engaged in each category of play was also calculated. Refer to Appendix D for detailed definitions of play categories.

#### *7.3.6 Social Skills Rating Scale – Teacher (SSRS-T)*

The SSRS-T (Gresham & Elliot, 1990) is a widely used scale for teachers' ratings of their students' overall social skills. This questionnaire has also been used for high-functioning children with autism in a number of research studies (Bauminger, 2002; Ozonoff & Miller,

1995). The SSRS-T provides a measure of children's cooperation (behaviours such as helping others, sharing materials and complying with rules and directions), assertion (behaviours such as asking for information and responding to the actions of others) responsibility (behaviours that demonstrate the ability to communicate with adults), and self control (behaviours that emerge in conflict situations such as responding appropriately to teasing, and in non conflict situations such as taking turns). Teachers' responses to each item were recorded using a three point scale (never, sometimes and very often). The Social Skills score from this scale was utilized for analysis.

The preschool form of this scale provides normative data for children aged from 3.00 to 4.11 years, and was used for 25 participants. The elementary school form of this scale provides normative data for children from kindergarten to year 6 and was used for 14 participants. The scale to be used (preschool or elementary) was determined by the age of the participant. Reliability coefficients for this scale range from .85 to .95 across social skill subscales.

### *7.3.7 Theory of Mind (ToM) Tasks*

Three first-order ToM tasks assessed the children's ability to make first order meta-representations and predict the thoughts, actions and emotions of another person based on their false belief. The first task was the 'Chris and Eddie Task', adopted from Carlson, Moses, and Hix (1998) who used an adaptation of Wimmer and Perner's (1983) task. This task required the children to infer the mental state of the protagonist (Chris) in the story in order to predict where he will look for a particular object. Successful completion of this task required the children to take into account the false belief held by this character. The exact wording and scoring of this task was taken from Carlson et al. (1998) and is described in Appendix E.

The second task, the 'Smarties Task', was devised by Perner et al. (1987). This task required participants to predict what the protagonist will say is in a smarties box by taking account of their false belief. The exact wording of the original task was adopted in the current

research, including the prompt and check questions assessing comprehension and memory. This task is described in Appendix F.

The third ToM task assessed the children's ability to make first order metarepresentations to predict how a protagonist would feel by taking account of their false belief (Fahie & Symons, 2003; Harris, Johnson, Hutton, Andrews, & Cooke, 1989). In this task two puppet monkeys (Mickey and Pingu) were introduced to the children. Following this, participants were told a story in which Pingu loved coke, but hated milk. The children were shown Pingu's can of coke before Pingu exited. Mickey then entered and poured the coke out of the can, replacing it with milk. Mickey exited and Pingu returned. Participants were told that he felt thirsty. Children were asked how Pingu felt before he looked in his can (emotion question), what Pingu thought was in the can (false belief), and other control questions. The exact wording and scoring described in Harris et al. (1989) was used. This task is described in Appendix G.

Following the administration of the ToM assessments, participants were allocated a score from 0 to 5. A score of 0 was allocated if the participant failed all tasks; 1.67, if the participant passed one task; 3.34 if the participant passed 2 tasks, and 5 if the participant passed all three tasks. A score out of 5.00 was utilized in order to equally weight social scores for the social functioning index (see Section 7.3.8).

#### *7.3.8 Social Functioning Index*

The scores for positive behaviours, play skills, SSRS-T and ToM were combined to provide a single index of social functioning. This was necessary to reduce the number of analyses in relation to sample size, and was justified on the basis that these variables are both statistically and theoretically related. This procedure is consistent with those employed in recent studies examining similar relationships in children with ASD (Clifford & Dissanayake, 2009).

To equally weight scores for comparison purposes, the positive behaviour score and the SSRS-T standard score were converted to a score out of 5.

To convert the SSRS-T standard score to a score out of 5, a score of 1.67 was assigned to participants whose standard score fell in the ‘below average’ range; a score of 3.34 was assigned to participants whose score fell in the ‘average’ range, and a score of 5.00 was assigned to participants whose score fell in the ‘above average’ range.

To convert the positive social behaviour score to a score out of 5, a score of 1 was assigned to participants who demonstrated positive social behaviour on 0 to 20 percent of intervals; a score of 2 was assigned to participants who demonstrated positive social behaviour on 21 to 40 percent of intervals; a score of 3 was assigned to participants who demonstrated positive social behaviour on 41 to 60 percent of intervals; a score of 4 was assigned to participants who demonstrated positive social behaviour on 61 to 80 percent of intervals; and a score of 5 was assigned to participants who demonstrated positive social behaviour on more than 80 percent of intervals. For all analyses, the converted score out of 5 for positive social behaviour, play skills, SSRS-T and ToM were used.

#### 7.4 Group Matching Procedures and Clinical Characteristics of Participants

Table 1 shows the means, standard deviations, and ranges, for participants with ASD and TD participants for cognitive, language, diagnostic and social assessments. The aim of the current study was to individually match children with ASD with TD children on gender and receptive language skills, however, this was not achieved. Instead a group-wise match on CA, NVIQ, expressive language skills and gender was obtained. The ASD group had significantly lower receptive and total language scores than TD participants. Participants with ASD also obtained significantly higher SCQ scores, and were significantly impaired on all measures of social behaviour relative to TD participants. These included social functioning, positive social behaviour, play skills, SSRS-T and ToM.

Table 1

*Mean scores, standard deviations, and ranges, for participants with ASD and TD participants for cognitive, language, diagnostic and social measures*

		ASD ( <i>n</i> = 20)	TD ( <i>n</i> = 19)	Statistic	<i>p</i> -value
Chronological age (months)					
	Mean (s.d)	60.45 (13.29)	56.37 (13.99)	<i>t</i> (37) = .93	.36
	Range	40 - 79	37 - 78		
NVIQ <sup>a</sup>					
	Mean (s.d)	112.05 (16.67)	116.84 (11.64)	<i>t</i> (37) = -1.04	.31
	Range	84 - 145	98 - 137		
Total Language <sup>b</sup>					
	Mean (SD)	97.85 (20.09)	108.74 (10.92)	<i>t</i> (29.63) = -	.04
	Range	50 - 131	94 - 135	2.12	
Receptive Language <sup>c</sup>					
	Mean (SD)	97.60 (19.46)	108.80 (10.45)	<i>F</i> (1, 37) = 4.93	.03
	Range	57 - 128	86 - 129		
Expressive Language <sup>d</sup>					
	Mean (SD)	98.20 (18.83)	106.79 (11.31)	<i>F</i> (1, 37) = 2.94	.10
	Range	50 - 126	92 - 139		
SCQ <sup>e</sup>					
	Mean (SD)	21.00 (6.45)	3.79 (2.72)	<i>t</i> (25.83) =	.001
	Range	12 - 35	1 - 9	10.96	
Positive Social Behaviour <sup>d</sup>					
	Mean (SD)	40.12 (25.78)	87.77 (10.31)	<i>t</i> (25.19) = -	.001
	Range	0 - 92	55 - 100	7.65	
Play Skills <sup>d</sup>					
	Mean (SD)	2.26 (0.74)	4.05 (0.67)	<i>t</i> (37) = 7.89	.001
	Range	1.00 - 3.72	2.50 - 4.83		
SSRS-T <sup>e</sup>					
	Mean (SD)	87.85 (15.73)	103.84 (13.50)	<i>t</i> (37) = -3.40	.002
	Range	49 - 103	78 - 123		
ToM <sup>f</sup>					
	Mean (SD)	0.92 (1.75)	3.34 (2.29)	<i>t</i> (37) = -3.70	.001
	Range	0 - 5	0 - 5		
Social Functioning <sup>g</sup>					
	Mean (SD)	8.34 (3.08)	15.63 (3.49)	<i>t</i> (37) = -6.29	.001
	Range	3.84 - 14.34	7.17 - 19.42		

*Note.* <sup>a</sup> Leiter International Performance Scale -Revised (Leiter-R) fast screening IQ score (Roid & Miller, 1997); <sup>b</sup>Preschool Language Scale 4<sup>th</sup> Edition (PLS-4) standard score (Zimmerman et al., 2002); <sup>c</sup> Social Communication Questionnaire (SCQ; Rutter et al., 2003); <sup>d</sup> Social Behaviour Coding Scheme (Bauminger, 2002); <sup>e</sup> Social Skills Rating Scale – Teacher (SRS-T; Gresham & Elliot, 1990); <sup>f</sup> First order Theory of Mind (ToM) tasks: Chris and Eddie Task (Carlson et al., 1998), Smarties Task (Perner et al., 1987), & emotional false belief task (Fahie & Symons, 2003; Harris et al., 1989); <sup>g</sup> Social Functioning index score derived from the positive social behaviour, play skills, SSRS-T and ToM scores.



## 7.5 General Procedures

Following ethics clearance from RMIT University (Faculty of Applied Science Human Research Ethics Committee; See Appendix H), children with an ASD were recruited from advertisements placed on parent internet support groups, and in centres specializing in early intervention for children with ASDs in Los Angeles, California. Additional participants were recruited through parent word-of-mouth. TD participants were recruited from advertisements placed in local day care centres, nursery schools, preschools, and through people known to the researcher (See Appendix I for the subject advertisement).

In most cases, the initial contact with participants was made by telephone. Participants either contacted the researcher by telephone, or provided their contact details for later contact by the researcher. During initial telephone contact, information was provided verbally about the aims and procedures of the research and parents' questions were answered. For parents who consented to their child participating in the research, an initial testing session was scheduled. In this session, parents were provided with a written description of the research (see Appendix J for the Plain Language Statement) and the informed consent form (see Appendix K) was reviewed and signed.

Each participant was tested individually during two, 1.5 to 2-hour sessions. Breaks were given as needed. The majority of participants were tested in their nearest Center for Autism and Related Disorders (CARD Inc.) office; however, due to scheduling difficulties, six participants with ASD and eight TD children were assessed in a quiet room in their home. There were no group differences in the number of participants who were assessed in their home ( $t(37) = -1.10, p = 2.77$ ).

After obtaining informed consent, diagnostic reports for participants with ASD were reviewed by the researcher. Participants' non-verbal IQ using the Leiter R (fast screening; Roid & Miller, 1997) was then assessed using standard administration procedures. The SCQ (Rutter, Bailey et al., 2003) was completed with parents, and the SSRS-T (Gresham & Elliot, 1990) was given to parents at the end of the session. It was requested that they have the form completed by the child's preschool or school teacher prior to the next testing session. For nineteen participants with ASD,

the SCQ was completed by the participants' mother. The SCQ was filled out by the participants' father in one case. For TD children, the SCQ was filled out by the participants' mother in eighteen cases, and the participants' father in one case.

Approximately two weeks after the initial testing session, children's verbal ability was assessed using the PLS-4 (Zimmerman et al., 2002). Standard administration procedures were used. Participants were then assessed using the social / non-social orienting task (Sweetenham et al., 1998) and the ToM tasks (Carlson et al., 1998; Harris et al., 1989; Perner et al., 1987). At a separate time within an approximate four-week period from the initial assessment, the social observation in the preschool or school setting was conducted.

Following testing, an assessment report was provided upon request to the parents of participants.

## 7.6 Statistical Analyses

Exploratory diagnostics were conducted on each dependent variable using SPSS (version 16) software (SPSS Inc., Chicago Illinois), in order to identify statistically significant skew, kurtosis, and equality of variance. When significant violations of the assumptions of parametric statistics were detected, linear transformations were attempted (Tukey, 1977), including logarithmic and square root expressions. For a number of variables, linear transformations were not successful in fully accommodating the assumptions of parametric analysis, often because of differences in the behavioural expression of participants with ASD and TD participants. For example, TD children spent essentially zero time unfocused, so these data necessarily showed almost no variability because of the floor effect. In contrast, the ASD group expressed greater variability due to spending more time unfocused.

As the assumptions of equality of variance and normality of the distribution were violated for the majority of variables, and linear transformations were unsuccessful in fully accommodating the assumptions of parametric analysis, non-parametric statistics were utilized using the original,

untransformed data. This guarded against the possibility that the metrical properties of response format somehow biased findings (Alreck & Settle, 2004; Mann & Whitney, 1947). Non-parametric statistics are parameter free, meaning that they make no assumptions regarding the shape of the raw data because they are calculated based on rankings rather than raw scores (Siegel, 1956). While non-parametric assessments are generally equivalent to parametric tests, the non-parametric statistics can be somewhat less powerful, because using rankings instead of actual scale values reduces the precision of the information (Mann & Whitney, 1947; Siegel, 1956). Therefore, compared to parametric analysis, the use of non-parametric analysis is a more conservative approach which is unaffected by extreme scores; however it may occasionally miss statistically significant differences because of reduced power (Howell, 2004; Keppel & Wickens, 2004).

To contrast ASD and TD participants in orienting attention to faces and non-facial stimuli in Aim 1 and Aim 2, the non-parametric Mann-Whitney *U* statistic was utilized. Wilcoxon Matched-Pairs Signed-Ranks Tests were then used to examine within-group differences in the distribution of attention to faces and non-facial stimuli. Similarly, for Aim 3, Aim 4, Aim 5, and Aim 6, Spearman's rank correlation coefficient ( $r_s$ ) were utilized (Corder & Foreman, 2009; Howell, 2004; Spearman, 1904). Correlations  $\leq 0.49$  were considered moderate, 0.50 to 0.74 strong, and  $\geq 0.75$  very strong (Portney & Watkins, 2009).

For all analyses, differences and relationships were considered statistically significant at a threshold of  $p < .05$ . However, due to the number of analyses in the current research, it could be argued that a more conservative alpha level should be set to guard against the inflated risk of erroneously rejecting the null hypothesis (type-I error; Portney & Watkins, 2000). Given the use of the more conservative non-parametric analysis, and subsequent increased risk of missing important group differences or relationships in this emerging field of research (type-II error), Bonferroni adjustments were not utilized due to the risk of increasing type-II error to unacceptable levels. This is consistent with recent research (Clifford & Dissanayake, 2009). However, significant differences or relationships  $p < .05$  and  $> .01$  should be viewed with caution.

## CHAPTER 8: GROUP DIFFERENCES IN ORIENTING ATTENTION TO FACES AND NON-FACIAL STIMULI

### 8.1 Chapter Overview

This chapter examines group differences in orienting attention to faces and non-facial stimuli. The relationships between the attention variables and the participant characteristic of CA and NVIQ are then analysed to determine whether these variables differentially impacted on the development of attention for children with ASD and TD children. For each section, the relevant statistical procedures, aims and hypothesis, and the results of the statistical analyses are presented. Finally, a brief discussion of the current findings in relation to previous research is presented.

### 8.2 Group Differences in Orienting Attention to Faces and Non-Facial Stimuli

Section 8.2 examines whether children with ASD are impaired in orienting attention to all stimuli, or specifically impaired in orienting attention to social stimuli relative to TD children. There were two Aims. Aim 1 was to examine participants' attention to faces and non-facial stimuli in the semi-naturalistic setting and Aim 2 was to examine participants' attention to social stimuli (faces) in the naturalistic social setting. There were two hypotheses for Aim 1 and one hypothesis for Aim 2. Data for Aims 1 and 2 were analysed using the Mann Whitney *U* test. Wilcoxon Matched-Pairs Signed-Ranks Tests were also used in Aim 2, to compare the within-group distribution of attention between faces and non-facial stimuli for each group. Data are presented in tables as means and standard deviations. Mann Whitney *U* results are presented in the text, and include the *U* score, the *z*-score, the associated *p*-value, and the effect sizes for each comparison. Wilcoxon Matched-Pairs Signed-Ranks Test results are presented in the text and include the *Z* score, associated *p*-value and effect size. Effect sizes  $\leq 0.1$  were considered small,  $\leq 0.3$  = medium, and  $\leq .5$  = large effect (Pallant, 2007). Bar graphs are presented to help the reader appreciate group similarities and differences.

Finally, the relationships between attention to faces and non-facial stimuli, and the participant characteristics of CA and NVIQ were examined using Spearman's *rho* ( $r_s$ ) correlation coefficients. Spearman's *rho* and *p*-values, are presented in table or text as appropriate. Correlations  $\leq 0.24$  were considered weak, 0.25 to 0.50 fair, 0.50 to 0.74 good or moderately strong, and  $\geq 0.75$  excellent or very strong (Portney & Watkins, 2009).

### 8.2.1 Statistical Analyses for Aim 1

Aim 1 was to examine whether there were group differences in the distribution of attention between faces and non-facial stimuli for participants with ASD and TD participants in the semi-naturalistic setting. For a full description of the experimental procedures, refer to Chapter 7, Section 7.3.4. Briefly, participants were presented with a series of toys in a room with a parent and examiner. The child's eye movements were video recorded, and later scored according to whether the child was fixated on faces, objects, bodies, or was unfocused. There were two hypotheses for Aim 1. For hypothesis 1, the mean number of attention shifts per minute was analysed. For hypothesis 2(i) the percentage of time fixated on faces and non-facial stimuli were analysed. For hypothesis 2(ii) the frequency of attention shifts between faces and categories of non-facial stimuli were analysed. For hypothesis 2(iii), the mean duration of fixations to faces and non-facial stimuli (in seconds) were analysed. Results for Aim 1 are presented by hypothesis. The mean scores for participants with ASD and TD participants for each of the attention variables examined in Aim 1 are presented in Table 2.

Table 2

*Mean scores and standard deviations for the attention variables for participants with ASD and TD participants*

Attention Variable	ASD (n = 20)	TD (n = 19)
Mean attention shifts p/min	12.11 (5.77)	13.37 (5.17)
Percentage of time fixated on faces	5.90 (4.83)	7.81 (8.40)
Percentage of time fixated on objects	85.79 (8.56)	87.32 (11.04)
Percentage of time fixated on bodies <sup>a</sup>	0.56 (0.82)	0.13 (0.27)
Percentage of time unfocused <sup>a</sup>	1.71 (2.95)	0.06 (0.14)
Mean shifts face ↔ face p/min	0.42 (.40)	0.85 (1.18)
Mean shifts face ↔ object p/min	5.19 (4.23)	6.54 (3.73)
Mean shifts face ↔ body p/min <sup>a</sup>	0.26 (0.34)	0.05 (0.19)
Mean shifts object ↔ object p/min	3.74 (2.17)	4.73 (2.46)
Mean shifts object ↔ body p/min <sup>a</sup>	0.50 (0.77)	0.02 (0.06)
Mean duration of fixations to faces	0.95 (0.37)	0.91 (0.38)
Mean duration of fixations to objects	8.71 (6.73)	6.73 (2.83)
Mean duration of fixations to bodies	0.47 (0.58)	0.27 (0.57)
Mean duration of time unfocused <sup>a</sup>	1.19 (2.35)	0.08 (0.15)

*Note.* <sup>a</sup> =  $p < .05$  Standard deviations are shown in parentheses; Mean duration of fixations are in seconds. Time spent moving is not displayed, thus percentages do not sum to 100%.

### *8.2.1.1 Hypothesis 1: Overall Attention Shifts per Minute*

The following analysis examined whether participants with ASD and TD participants differed in their mean number of attention shifts per minute. It was hypothesised that children with ASD would show a general impairment in orienting attention, as evidenced by fewer shifts of attention per minute relative to TD participants. The dependent variable was the mean number of attention shifts per minute. The independent variable was group (ASD or TD).

The results revealed that there were no statistically significant group differences in the mean number of attention shifts per minute ( $U = 159.50, z = -0.86, p = .39, r = .14$ ) for participants with ASD and TD participants.

#### *8.2.1.2 Hypothesis 2(i) Time Fixated on Faces and Non-Facial Stimuli*

The following analyses examined whether children with ASD and TD children differed in the percentage of time they spent fixated on faces and non-facial stimuli. It was hypothesised that children with ASD would fixate on faces for a lower percentage of time, and non-facial stimuli (objects, bodies and unfocused) for a higher percentage of time than TD children. The four dependent variables were the percentage of time fixated on objects, people, bodies and ‘unfocused.’ The independent variable was group (ASD or TD).

Participants with ASD spent a significantly higher percentage of time fixated on bodies ( $U = 115.50, z = -2.31, p = .02, r = .37$ ) and unfocused ( $U = 109.00, z = -2.55, p = .01, r = .41$ ) than TD participants. There were no statistically significant group differences in the percentage of time fixated on faces ( $U = 166.00, z = -0.67, p = .50, r = .11$ ) or objects ( $U = 149.00, z = -1.15, p = .25, r = .18$ ).

To further examine participants’ distribution of attention between faces and non-facial stimuli, the within-group distribution of attention was examined for each group. The results revealed that participants with ASD and TD participants spent a significantly higher percentage of time fixated on objects than faces (ASD Group, Wilcoxon  $Z = -3.92, p = .001, r = .62$ ; TD Group, Wilcoxon  $Z = -3.82, p = .001, r = .62$ ), bodies (ASD Group, Wilcoxon  $Z = -3.92, p = .001, r = .62$ ; TD Group, Wilcoxon  $Z = -3.82, p = .001, r = .62$ ) or unfocused (ASD Group, Wilcoxon  $Z = -3.92, p = .001, r = .62$ ; TD Group, Wilcoxon  $Z = -3.82, p = .001, r = .62$ ).

Both groups of participants also spent a higher percentage of time fixated on faces than bodies (ASD Group, Wilcoxon  $Z = -3.62, p = .001, r = .57$ ; TD Group, Wilcoxon  $Z = -3.82, p = .001, r = .62$ ) or unfocused (ASD Group, Wilcoxon  $Z = -2.61, p = .01, r = .41$ ; TD Group, Wilcoxon  $Z = -3.82, p = .001, r = .62$ ). There were no statistically significant differences in the percentage of time spent fixated on bodies or unfocused for either group of participants (ASD

Group, Wilcoxon  $Z = -1.49$ ,  $p = .14$ ,  $r = .24$ ; TD Group, Wilcoxon  $Z = -1.01$ ,  $p = .31$ ,  $r = .16$ ).

Refer to Figure 1 for the mean percentage of time fixated on faces, objects, bodies and unfocused for participants with ASD and TD participants.

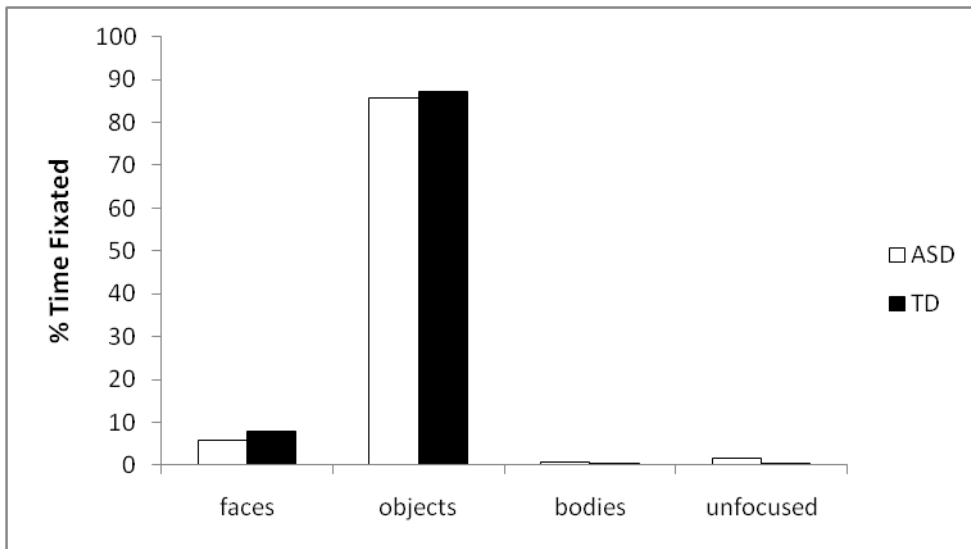


Figure 1 Mean percentage of time fixated on faces, objects, bodies and unfocused for participants with ASD and TD participants. The height of each bar represents the % of time fixated.

### 8.2.1.3 Hypothesis 2(ii): Attention Shifts between Faces and Non-Facial Stimuli

The following analyses examined whether participants with ASD and TD participants differed in the distribution of attention shifts between faces and categories of non-facial stimuli. It was hypothesised that children with ASD would make significantly fewer shifts of attention between faces (face ↔ face) and faces and non-facial stimuli (face ↔ object, face ↔ body), and significantly more attention shifts between non-facial stimuli (object ↔ object, object ↔ body) per minute than TD children. The independent variables were the mean number of attention shifts per minute between faces, the mean number of attention shifts per minute between faces and objects, the mean number of attention shifts per minute between faces and bodies, the mean number of attention shifts per minute between objects, and the mean number of shifts per minute between bodies and objects. There were no attention shifts between bodies for either



group of participants, so this variable was removed from these and all subsequent analyses. The independent variable was group (ASD or TD).

Participants with ASD made significantly more attention shifts per minute between objects and bodies ( $U = 106.00, z = -2.89, p = .004, r = .46$ ), and faces and bodies ( $U = 106.00, z = -2.82, p = .01, r = .45$ ), than TD participants. The statistically significant group difference in the mean frequency of attention shifts between faces and bodies was in the opposite direction of prediction. There were no statistically significant group differences in the mean number of attention shifts per minute between faces, ( $U = 165.50, z = -0.70, p = .48, r = .11$ ) faces and objects ( $U = 133.00, z = -1.60, p = .11, r = .26$ ) and objects, ( $U = 154.50, z = -0.99, p = .32, r = .16$ ) for participants with ASD and TD participants.

To further examine participants' distribution of attention between faces and non-facial stimuli, the within-group distribution of attention was examined for each group. The results revealed there were no statistically significant differences in the mean number of attention shifts per minute between faces and objects (face ↔ object) and objects (object ↔ object) for either group of participants (ASD Group, Wilcoxon  $Z = -1.23, p = .22, r = .19$ ; TD Group, Wilcoxon  $Z = -1.25, p = .21, r = .20$ ). However, both groups of participants made significantly more attention shifts per minute between faces and objects (face ↔ object) than faces (face ↔ face) (ASD Group, Wilcoxon  $Z = -3.92, p = .001, r = .62$ ; TD Group, Wilcoxon  $Z = -3.83, p = .001, r = .62$ ), faces and bodies (ASD Group, Wilcoxon  $Z = -3.92, p = .001, r = .62$ ; TD Group, Wilcoxon  $Z = -3.83, p = .001, r = .62$ ), and objects and bodies (ASD Group, Wilcoxon  $Z = -3.81, p = .001, r = .60$ ; TD Group, Wilcoxon  $Z = -3.82, p = .001, r = .62$ ).

Participants with ASD and TD participants also made more attention shifts per minute between objects (object ↔ object) than faces (face ↔ face) (ASD Group, Wilcoxon  $Z = -3.87, p = .001, r = .61$ ; TD Group, Wilcoxon  $Z = -3.50, p = .001, r = .57$ ), faces and bodies (ASD Group, Wilcoxon  $Z = -3.87, p = .001, r = .61$ ; TD Group, Wilcoxon  $Z = -3.82, p = .001, r = .62$ ), and objects and bodies (ASD Group, Wilcoxon  $Z = -3.62, p = .001, r = .57$ ; TD Group, Wilcoxon  $Z = -3.82, p = .001, r = .62$ ).

While TD children made more attention shifts per minute between faces (face ↔ face) than faces and bodies (Wilcoxon  $Z = -3.30, p = .001, r = .54$ ) and objects and bodies (Wilcoxon  $Z = -3.18, p = .001, r = .52$ ), participants with ASD did not differ in the mean frequency of their attention shifts between faces (face ↔ face) and faces and bodies (Wilcoxon  $Z = -1.44, p = .15, r = .23$ ), and objects and bodies (Wilcoxon  $Z = -.11, p = .91, r = .02$ ).

Finally, neither participants with ASD nor TD participants differed in their mean number of attention shifts per minute between faces and bodies, and objects and bodies (ASD Group, Wilcoxon  $Z = -1.28, p = .20, r = .20$ ; TD Group, Wilcoxon  $Z = -.38, p = .71, r = .06$ ). Refer to Figure 2 for the mean number of attention shifts per minute by category of shift, for participants with ASD and TD participants.

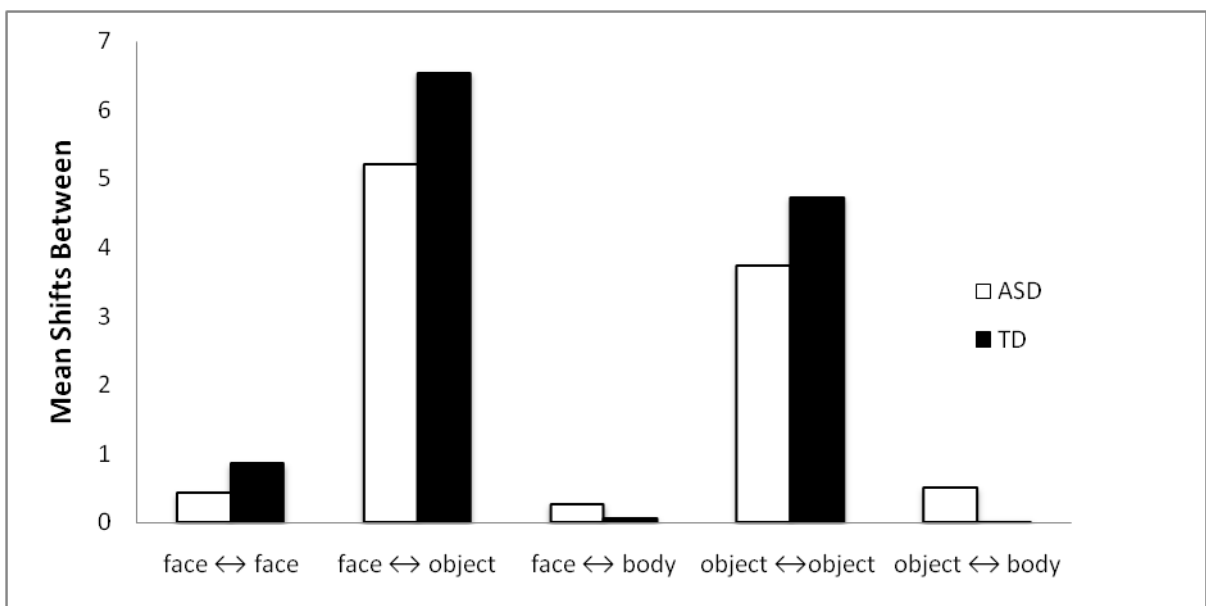


Figure 2 The mean number of attention shifts per minute, by category of shift, for participants with ASD and TD participants. The height of each bar represents the mean scores.

#### 8.2.1.4 Hypothesis 2(iii): Duration of Fixations to Faces and Non-Facial Stimuli

The following analyses examined whether participants with ASD and TD participants differed in the mean duration of their fixations to faces and non-facial stimuli. It was hypothesised that children with ASD would show a lower level of attentional engagement to

social stimuli, as evidenced by significantly shorter mean fixations to faces; and a higher level of engagement to non-facial stimuli (objects, bodies and unfocused), as evidenced by significantly longer mean fixations to these regions. Four dependent variables were used: the mean duration of fixations to objects, faces, bodies and unfocused. The independent variable was group (ASD or TD).

Participants with ASD were unfocused for significantly longer mean durations than TD participants,  $U = 109.00$ ,  $z = -2.55$ ,  $p = .01$ ,  $r = .41$ . Participants with ASD also fixated on bodies for somewhat longer durations than TD participants. This finding approached, however, failed to reach statistical significance,  $U = 132.00$ ,  $z = -1.80$ ,  $p = .07$ ,  $r = .29$ . There were no statistically significant group differences in the mean duration of fixations to faces ( $U = 180.00$ ,  $z = -.28$ ,  $p = .78$ ,  $r = .04$ ) or objects ( $U = 178.00$ ,  $z = -.34$ ,  $p = .75$ ,  $r = .05$ ).

To further examine participants' distribution of attention between faces and non-facial stimuli, the within-group distribution of attention was examined for each group. The results revealed that participants with ASD and TD participants fixated on objects for significantly longer durations than faces (ASD Group, Wilcoxon  $Z = -3.92$ ,  $p = .001$ ,  $r = .62$ ; TD Group, Wilcoxon  $Z = -3.82$ ,  $p = .001$ ,  $r = .62$ ), bodies (ASD Group, Wilcoxon  $Z = -3.92$ ,  $p = .001$ ,  $r = .62$ ; TD Group, Wilcoxon  $Z = -3.82$ ,  $p = .001$ ,  $r = .62$ ) or were unfocused (ASD Group, Wilcoxon  $Z = -3.92$ ,  $p = .001$ ,  $r = .62$ ; TD Group, Wilcoxon  $Z = -3.82$ ,  $p = .001$ ,  $r = .62$ ).

Both groups of participants also fixated on faces for significantly longer durations than bodies (ASD Group, Wilcoxon  $Z = -2.80$ ,  $p = .01$ ,  $r = .44$ ; TD Group, Wilcoxon  $Z = -2.82$ ,  $p = .01$ ,  $r = .46$ ). However, while TD participants fixated on faces for significantly longer durations than they were unfocused (Wilcoxon  $Z = -3.82$ ,  $p = .001$ ,  $r = .62$ ), participants with ASD did not differ in the mean duration of time spent fixated on faces or unfocused (Wilcoxon  $Z = -.86$ ,  $p = .39$ ,  $r = .14$ ).

Finally, neither children with ASD nor TD children differed in the mean duration of their fixations to bodies or time spent unfocused (ASD Group, Wilcoxon  $Z = -.59$ ,  $p = .55$ ,  $r = .09$ ; TD Group, Wilcoxon  $Z = -1.19$ ,  $p = .24$ ,  $r = .19$ ). Refer to Figure 3 for the mean duration

of fixations for each type of stimulus in seconds for participants with ASD and TD participants.

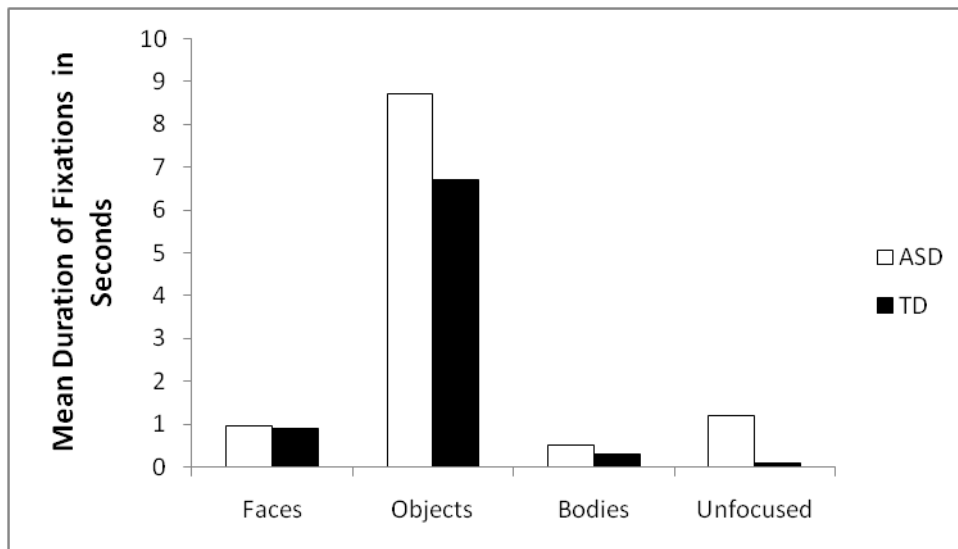


Figure 3 The mean duration of fixations for each type of stimulus in seconds for participants with ASD and TD participants. The height of each bar represents the mean scores.

#### 8.2.1.5 Group Differences in Attention to Parent and Researcher

In order to determine whether the time spent orienting to faces was influenced by the familiarity of the face to be viewed for children with ASD or TD children, the following analyses were conducted to identify whether the groups differed in the overall percentage of time spent fixated on the parent versus researcher's face, the frequency of attention shifts to the parent versus researcher's face, and the mean duration of fixations to the parent versus researcher's face. Analyses were also conducted to determine whether there were within-group differences in the percentage of time spent viewing the parent versus the researcher's face within the overall time spent fixated on faces.

There were no statistically significant group differences in the overall percentage of time children with ASD and TD children spent viewing the face of the parent ( $U = 173.50, z = -0.46, p = .64, r = .07$ ) or researcher ( $U = 153.00, z = -1.04, p = .30, r = .04$ ), the mean number of attention shifts per minute to the face of the parent ( $U = 159.50, z = -0.86, p = .39, r = .14$ ) or researcher ( $U = 146.50, z = -1.23, p = .22, r = .20$ ), or the average duration of fixations to the parent ( $U = 168.00, z = -0.09, p = .93, r = .01$ ) or researcher's ( $U = 168.00, z = -0.09, p = .93, r = .01$ ).

= .01) face. Finally, there were no group differences on the percentage of time spent looking at the parent ( $U = 181.00, z = -0.25, p = .80, r = .04$ ) or researcher ( $U = 185.00, z = -0.14, p = .89, r = .02$ ) within the overall time fixated on faces.

Within-group comparisons examining the distribution of attention within the overall time fixated on faces, revealed that neither children with ASD nor TD children differed in the percentage of time spent fixated on the parent or researcher (ASD Group, Wilcoxon  $Z = -.82, p = .41, r = .13$ ; TD Group, Wilcoxon  $Z = -1.41, p = .16, r = .23$ ). Refer to Table 3 for the mean scores and standard deviations for the distribution of attention between the parent and researcher for participants with ASD and TD participants.

Table 3

*Mean scores and standard deviations for the distribution of attention between the parent and researcher for participants with ASD and TD participants*

Attention Variable	ASD (n = 20)	TD (n = 19)
Percentage of overall time fixated on parent's face	3.18 (2.66)	4.77 (6.74)
Percentage of overall time fixated on researcher's face	2.72 (4.03)	3.04 (2.70)
Mean shifts to parent p/min	1.99 (1.61)	3.76 (5.16)
Mean shifts to researcher p/min	1.78 (2.06)	5.87 (17.64)
Mean duration of fixations to parents	1.03 (0.69)	0.93 (0.44)
Mean duration of fixations to researcher	0.71 (0.40)	0.80 (0.51)
Percentage of time fixated on faces, fixated on parent	57.52 (32.38)	55.83 (29.23)
Percentage of time fixated on faces, fixated on researcher	42.48 (32.38)	39.17 (27.33)

*Note.* Standard deviations are shown in parentheses; Mean duration of fixations are in seconds.

#### 8.2.1.6 Summary for Aim 1

TD children and those with ASD did not differ in the mean number of attention shifts per minute. Further analyses of the distribution of attention between faces and non-facial

stimuli revealed that there were no group differences in the amount of time spent fixated on faces or objects, however, children with ASD spent more time fixated on bodies, or unfocused, than TD children. Finally, there were no group differences in the mean number of attention shifts per minute between faces (face ↔ face), objects (object ↔ object), and faces and objects (face ↔ object), however, participants with ASD made significantly more attention shifts between faces and bodies (face ↔ body) and objects and bodies (object ↔ body), than TD children.

Within-group analyses of the distribution of attention between faces and non-facial stimuli revealed that both ASD and TD participants spent most of the recording time looking at objects. Both groups of participants also spent more time looking at faces than bodies. However, while TD children spent more time fixated on faces than they were unfocused, children with ASD did not differ in the amount of time spent fixated on faces or unfocused. Finally, analyses of the distribution of attention shifts showed that both ASD and TD participants shifted attention between objects and faces significantly more frequently than any other type of shift, followed by attention shifts between objects. However, while TD children made more attention shifts per minute between faces (face ↔ face) than faces and bodies (face ↔ body) and objects and bodies (object ↔ body), children with ASD did not differ in the frequency of these types of attention shifts.

Finally, analyses of the distribution of attention between the parent and researcher failed to find group differences in the percentage, duration, or mean number of fixations to the faces of the parent versus researcher for children with ASD or TD children. However, TD children demonstrated more variability in their scores for the percentage of overall time fixated on the parent's face, mean number of attention shifts to parent and mean number of attention shifts to researcher than children in the ASD group, as evidenced by higher standard deviations.

### 8.2.2 Statistical Analysis for Aim 2 and Hypothesis 3: Fixations to Peers' Faces in the Naturalistic Setting

Aim 2 was to examine whether there were group differences in attention to social stimuli (faces) in the naturalistic social setting for participants with ASD and TD participants. Refer to Chapter 7, Section 7.3.5.1 for a full description of the experimental procedures used. Briefly, participants were observed during a period of unstructured social interaction with peers in the preschool or school setting. For each 50-second interval, the presence or absence of looking at the face of a peer was recorded. The percentage of intervals fixated on peers' faces was then calculated.

The following analysis examined whether children with ASD and TD children differed in the frequency of fixations to peers' faces in the naturalistic setting. It was hypothesised that participants with ASD would make fixations to peers' faces on significantly fewer observation intervals than TD participants. The independent variable was the mean percentage of observation intervals in which the child fixated on peers' faces in the naturalistic social setting. The independent variable was group (ASD or TD).

Children with ASD fixated on peers' faces on significantly fewer observation intervals ( $M = 32.60$ ,  $SD = 24.42$ ) than TD children ( $M = 83.10$ ,  $SD = 17.83$ ). This group difference was statistically significant,  $U = 19$ ,  $z = -4.81$ ,  $p = .001$ ,  $r = .77$ .

### 8.3 Relationships between CA, NVIQ and Attention Variables

The following analyses examined whether the participant characteristic variables, CA and NVIQ, were related to attention variables in children with ASD and TD children. For participants with ASD, there was a moderately strong, negative, relationship between the percentage of overall time fixated on faces and CA,  $r_s = -.52$ ,  $p = .02$ . There was also a fair, negative relationship between the percentage of overall time unfocused and NVIQ, ( $r_s = -.46$ ,  $p = .04$ ), and the average duration of time unfocused and NVIQ,  $r_s = -.46$ ,  $p = .04$ . Finally, there

was a fair, negative relationship between the mean number of attention shifts per minute between faces and objects and CA that approached statistical significance,  $r_s = -.44$ ,  $p = .06$ . There were no other statistically significant relationships between the attention variables and characteristic variables of CA and NVIQ for these participants.

For TD participants, there was a moderately strong, positive relationship between the average duration of fixations to objects and CA ( $r_s = .64$ ,  $p = .003$ ), and a moderately strong, negative, relationship between the mean number of attention shifts per minute and CA,  $r_s = -.58$ ,  $p = .009$ . There was also a fair, negative relationship between the percentage of overall time looking at bodies and NVIQ, ( $r_s = -.46$ ,  $p = .05$ ), a fair, positive relationship between the average duration of fixations to objects and NVIQ ( $r_s = .44$ ,  $p = .05$ ), and a fair, negative relationship between the average duration of fixations to bodies and NVIQ ( $r_s = -.45$ ,  $p = .06$ ) that approached, however failed to achieve statistical significance. There were no other statistically significant relationships between the attention variables and characteristic variables of CA and NVIQ for TD children.

### *8. 3.1 Summary of the Relationships between CA, NVIQ and Attention Variables*

There were a number of statistically significant relationships between the attention variables and CA and NVIQ for both TD children and those with ASD. Younger children with ASD spent more overall time looking at faces than older participants. Additionally children with ASD and a lower NVIQ spent more of their overall time unfocused and were unfocused for longer durations than children with a higher NVIQ. Finally, older TD children spent more time fixated on objects and made fewer overall attention shifts than younger children. Refer to Table 4 for a summary of the relationship between attention variables and CA and NVIQ for participants with ASD and TD participants.



Table 4

*Summary of the relationships between attention variables and CA and NVIQ for participants with ASD and TD participants*

Variable	ASD		TD	
	CA	NVIQ	CA	NVIQ
<b>Semi-Naturalistic Setting</b>				
Mean number of attention shifts p/min			b	
Percentage of time fixated on objects				
Percentage of time fixated on faces	b			
Percentage of time fixated on bodies				
Percentage of time unfocused		b		
Mean shifts p/min from face ↔ face				
Mean shifts p/min from object ↔ object				
Mean shifts p/min from face ↔ object				
Mean shifts p/min from face ↔ body				
Mean shifts p/min from object ↔ body				
Mean duration of fixations to objects			a	
Mean duration of fixations to faces				
Mean duration of fixations to body				
Mean duration of time unfocused		b		
<b>Naturalistic Setting</b>				
Percentage of intervals fixated on peers' faces				

*Note.* <sup>a</sup> blue represents a positive relationship. <sup>b</sup> yellow represents a negative relationship.

## 8.4 Review and Discussion of Group Differences in Orienting Attention to Faces and Non-Facial Stimuli

### 8.4.1 General Orienting Ability

The hypothesis that children with ASD would show a general impairment in orienting attention, as evidenced by fewer shifts of attention per minute relative to TD children, was not

supported. There were no significant group differences in the mean frequency of attention shifts per minute between participants with ASD and TD participants. These findings are consistent with Van der Geest et al. (2001) who reported that 10-year-old children with ASD did not differ from TD children in the length of their scan path and number of visual fixations to drawings of social scenes, and with Pascualvaca et al. (1998), who reported that children with ASD were unimpaired in their ability to continuously shift attention while comparing and contrasting the features of computerized stimuli. These findings are also consistent with previous studies that failed to find evidence of impaired disengagement (Kawakubo et al., 2004) or shifting attention (Iarocci & Burack, 2004) in individuals with ASD using computerized visuospatial cueing tasks.

The failure to find group differences in the overall frequency of attention shifts per minute is inconsistent with Swettenham et al. (1998) who, using the same methodology, reported that toddlers with ASD made fewer overall shifts of attention than DD and TD participants. However, further analyses by Swettenham et al. revealed that while participants with ASD made significantly fewer attention shifts involving social stimuli (faces) than TD and DD participants, they did not differ in the frequency of attention shifts between objects. Swettenham et al. concluded that participants with ASD were unimpaired in their ability to shift attention across sources of non-social stimuli and thus did not demonstrate a general orienting impairment. The notion that individuals with ASD do not show a general orienting impairment is supported by the present findings.

The current findings are inconsistent with Dawson et al. (1998; 2004), who reported that children with ASD oriented significantly less frequently to both social and non-social auditory stimuli, relative to children with Down Syndrome (Dawson et al., 2004) and TD children (Dawson et al., 1998). However, Dawson et al. (1998; 2004) assessed orienting responses to auditory stimuli presented in discrete trials (Dawson et al., 1998; 2004) while social orienting was conceptualized as spontaneous visual fixation patterns to visual stimuli in the current study. Thus, the different findings obtained may reflect the differential responses of children with ASD to auditory versus visual stimuli.

The majority of the previous studies examining visuospatial orienting in ASD assessed response times to disengage and shift attention. In general, these studies reported that individuals with ASD were slower to disengage and shift attention relative to other groups (Courchesne et al., 1994; Elsabbagh et al., 2009; Harris et al., 1999; Kawakubo et al., 2007; Landry & Bryson, 2004; Renner et al., 2006; Swettenham et al., 1998; Townsend et al., 1996; 1999; Wainwright-Sharp & Bryson, 1993; Zwaigenbaum et al., 2005). In the current study, the lack of group differences in the frequency of attention shifts per minute fails to support the notion of slowed visuospatial orienting in ASD. However, there were several key methodological variations between the previous research studies and the current study that may account for these discrepant findings. First, the aforementioned research (e.g., Courchesne et al., 1994; Elsabbagh et al., 2009; Harris et al., 1999; Kawakubo et al., 2007; Landry & Bryson, 2004) examined the speed of orienting in response to a cue to shift attention. However, in the current study, the frequency of uncued attention shifts in a semi-naturalistic setting was examined. Slowed visuospatial orienting in the previous studies may therefore result from difficulties interpreting the cue or cue-target relationship, and preparing a saccade towards the target rather than in continuously shifting attention per se. This notion that slowed visuospatial orienting stems from an impaired ability to interpret the cue or cue-target relationship is supported in previous research (Bowler, 2007; Iarocci & Burack, 2004; Leekam, Lopez & Moore, 2000).

Related to this, previous research suggests that individuals with ASD are impaired in endogenous but not exogenous orienting (Courchesne et al., 1994; Harris et al., 1999; Iarocci & Burack, 2004; Townsend et al., 1999). Due to the absence of cues to shift attention in the current study, it is possible that many of the attention shifts were exogenous in nature, and were driven by the physical features of the stimuli, such as colour and degree of contrast. The current findings may thus reflect intact exogenous orienting of attention. As exogenous and endogenous attention shifts were not differentiated in the current study, this interpretation is speculative; however it is consistent with the current finding of unimpaired attentional shifting in the absence of specific attentional cueing.

Finally, there were significant differences in the stimuli utilized in the current study relative to previous research studies that may account for these discrepant findings. Orienting to sources of both social and non-social stimuli were examined in the current study, whereas research using Posner and gap-overlap paradigms exclusively examined orienting to non-social stimuli. Additionally, participants were physically interacting with a selection of real-life and naturally appealing toys in the current study, whereas the majority of previous studies utilized stimuli presented on a computer screen. Differences in the stimuli may have influenced the frequency with which participants' shifted their attention between the stimuli in two ways. First, Bowler (2007) reported that impairments disengaging and shifting attention may be related to the degree to which the stimuli capture the attention of the individual with ASD. In support, longer latencies to disengage and shift attention were observed in studies where the child was required disengage attention from bright, dynamic stimuli. Thus, the visual displays used in the previous studies may have been more engaging than the stimuli used in the current study, resulting in a more pronounced impairment in disengaging attention. Alternatively, the real-life and naturally appealing toys utilized in current study may have increased children's motivation to visually explore the stimuli to a greater extent than stimuli presented on a computer screen. The ability to interact physically with the stimuli may have further increased the frequency with which participants' shifted their attention in the current study. The notion that children with ASD may show an intact ability to shift attention when engaged with real-life and age-appropriate stimuli was supported by Swettenham et al. (1998) who, using real-life toys, reported that toddlers with ASD were unimpaired in their ability to shift attention between objects.

Correlational analyses examining the possible confounding effects of participant characteristics (CA, NVIQ) on the frequency of attention shifts revealed that older TD participants made fewer attention shifts than their younger counterparts. This finding may be consistent with previous research documenting age-related increases in the sustained attention skills of TD children (Ruff & Capozzoli, 2003). While participants with ASD showed a similar pattern of results, the relationship between CA and the mean number of attention shifts per

minute failed to achieve statistical significance. This is consistent with previous research (Klin et al., 2002). The lack of a statistically significant relationship between the mean frequency of attention shifts and NVIQ for either children with ASD or TD children was also supported by previous research (Kawakubo et al., 2007; Landry & Bryson, 2004).

#### *8.4.2 Orienting to Faces and Non-Facial Stimuli*

##### *8.4.2.1 Orienting to Faces*

Analyses of the distribution of attention between faces and non-facial stimuli failed to support the hypothesis that participants with ASD would demonstrate a specific impairment in orienting attention to social stimuli (faces) in the semi-naturalistic setting. The hypotheses that participants with ASD would fixate on faces for a lower percentage of time, fixate on faces for shorter mean durations, and make fewer overall attention shifts involving faces, relative to TD participants, were not supported. Both groups of participants spent a similar percentage of overall time fixated on faces, fixated on faces for a similar duration, and made a comparable number of attention shifts between faces, and faces and non-facial stimuli. The results further revealed that, contrary to predictions, participants with ASD made significantly more attention shifts between faces and bodies relative to TD participants. However, in the naturalistic setting, the hypothesis that participants with ASD would fixate on peers' faces on significantly fewer observation intervals than TD participants was supported. Orienting to peers' faces in the naturalistic setting was the best predictor of group membership. Participants with ASD oriented to peers' faces on 32.6 % of intervals compared to 83.1% of intervals for TD participants. Taken together, these findings indicate that children with ASD are unimpaired in orienting to salient social stimuli (faces) in more structured, semi-naturalistic settings, however, are significantly impaired in orienting to social stimuli in the naturalistic social setting.

Analyses examining whether unimpaired orienting in the semi-naturalistic setting was due to the presence of a parent in this setting failed to support the notion that children with ASD were more likely to fixate on highly familiar and potentially motivating individuals (e.g., their parents) as opposed to a less-well known or unfamiliar individual, the researcher. Children

with ASD and TD children did not differ in the amount of time spent looking at the parent versus the researcher, and made a comparable number of attention shifts to the face of the parent and researcher. As no previous research examining whether children with ASD orient more frequently to their parents relative to other adults has been identified, these findings require replication. However, previous research indicates that children with ASD are more likely to initiate interaction with their mothers, relative to other individuals (Adamson et al., 2001; Naber et al., 2007). Taken together these findings suggest that while children with ASD may look at the face of other adults as frequently as their parents, at least in relatively structured settings, they are less likely to initiate social interactions with them. However, as social interaction bids were not examined in the semi-naturalistic setting, this issue requires further consideration. Additionally, as orienting to parents was only examined in the semi-structured setting in the current study, the extent to which the presence of a parent impacts on the orienting behaviour of children with ASD in more complex social settings remains unclear.

The finding of impaired social orienting in ASD when viewing stimuli in the naturalistic setting is consistent with studies demonstrating that young infants and toddlers with ASD pay less attention to social stimuli, making eye-contact, orienting to their name, and fixating on faces significantly less frequently than TD and DD participants (Baranek, 1999; Clifford et al., 2007; Maestro et al., 2005; Osterling et al., 2002; Osterling & Dawson, 1994; Watson et al., 2007; Werner et al., 2000; 2005). However, using retrospective video analyses, Baranek et al. (1999) failed to find group differences in the frequency with which infants with ASD oriented to people's faces, relative to TD and DD infants. The authors attributed the lack of group differences to difficulties analysing eye movements from video footage obtained in the naturalistic setting, and difficulties distinguishing infants with ASD from other infants on the basis of social orienting behaviour prior to 12 months of age.

The extent to which individuals with ASD are impaired in orienting to social stimuli in less realistic (or ecologically valid) settings is less clear. Swettenham et al. (1998) reported that toddlers with ASD spent significantly less time looking at faces than TD and DD participants in the semi-naturalistic setting. Several other researchers established that individuals with ASD

spent a significantly lower percentage of time fixated on the eye region of the face relative to other groups of individuals when viewing movies (Jones et al., 2008; Klin et al., 2002; Norbury et al., 2009; Riby & Hancock, 2009a; Speer et al., 2007) or pictures (Riby & Hancock, 2008; 2009a; 2009b) depicting social and non-social stimuli. Other researchers failed to find evidence of impaired social orienting in individuals with ASD when viewing less complex and ecologically valid social stimuli (Fletcher-Watson et al., 2008; Speer et al., 2007; Van der Geest et al., 2001). The conflicting findings regarding the nature of social orienting in individuals with ASD may be attributed to the considerable heterogeneity in the design and methodology employed across studies. Pertinent factors include specific participant characteristics such as age, diagnosis, and severity of ASD-related symptomatology. The social orienting behaviour of children with ASD in the semi-naturalistic setting in the current study may have also been enhanced as a result of explicit learning in their early-intervention programs. This issue will be further discussed in Chapter 10, Section 10.2. Additionally, the discrepant findings between the current and previous studies may relate to the context and social complexity of the stimuli presented; with social orienting impairments for individuals with ASD reportedly more pronounced in more complex social settings (Speer et al., 2007). These issues will be further discussed in Chapter 10, Section 10.2. Finally, while several previous studies have reported that individuals with ASD spend less time fixated on eyes, and more time fixated mouths than TD individuals (Klin et al., 2002), visual fixations to the eye or mouth regions of the face were not differentiated in the current study. Thus, it is possible that the failure to find group differences in orienting attention to faces in the current study may have reflected increased fixations to the mouth region, as opposed to visual fixations to eyes as usually occurs in TD populations. As it was not possible to accurately differentiate between fixations to the eye and mouth region using the methodology employed in the current study, this hypothesis requires further investigation.

However, both ASD and TD participants in the current study spent a considerably lower percentage of overall time looking at faces in the semi-naturalistic setting (ASD = 5.90%; TD = 7.81%) than the percentage of overall time fixated on faces (i.e., the sum of the

percentage of time fixated on the eyes and mouth) reported by Klin et al. (2002; ASD = 65.8%; TD = 86.6%), Norbury et al. (2009; ASD non-language impaired = 39.7%; TD = 49.9%) and Jones et al. (2008; ASD= 69.1%; TD = 77.8%). Reduced fixation times to faces for both groups of participants in the current study may be related to differences in the non-social stimuli utilized, resulting in more time fixated on objects for these participants.

In the semi-naturalistic setting in the current study, children were engaged in free-play with novel, age-appropriate toys that were featured prominently in the environment. While people (i.e., the researcher and parent) were present, they were not engaged in social interaction with each other, nor with the child, unless the interaction was initiated by the child. As a result, it is possible that the non-social stimuli (i.e., toys) in the current study were considerably more salient than the social stimuli (i.e., faces), creating a context in which reduced fixations to faces was appropriate for both groups of children (e.g., because they were playing with toys). Group differences in the time spent attending to faces in this setting may thus have been minimized as a result of decreased attention to faces for TD children. However in previous studies (e.g., Jones et al., 2008; Klin et al., 2002; Norbury et al., 2009), non-social stimuli were common household or environmental objects that may not naturally attract attention, while social stimuli were dynamic and interactive. Furthermore, faces and / or social interactions were featured, while the non-social aspects of the scene were minimised. As a result, it is likely that the social stimuli utilized in these studies were more salient than the non-social stimuli, resulting in more time fixated on faces for both groups of participants. It appears that when viewing salient social stimuli, individuals with ASD fail to direct their attention to socially salient stimuli to the same degree as TD children, resulting in significantly less time spent fixated on salient social stimuli in these settings. This issue will be further discussed in Chapter 10, Section 10.2.

The notion that both TD children and those with ASD spend more time fixated on objects than faces when engaged in play with highly motivating, age-appropriate toys was supported by Swettenham et al. (1998), who reported that toddlers with ASD, DD and TD toddlers spent considerably less time fixated on faces than objects when engaged in free play with toys. The relative salience of the toys utilized in the current study and in the study of



Swettenham et al. (1998) may have been further heightened by the young age of participants in these studies, relative to Klin et al. (2002) and Norbury et al. (2009); in these studies participants were adolescents and young adults. The importance of toy-play for young children is well documented in the research literature (Rowland & Schweigert, 2009; Williams, 2003).

An examination of the relationships between visual fixation patterns to faces and participant CA and IQ, revealed that older participants with ASD spent less time fixated on faces than younger participants. This finding is inconsistent with several previous researchers, who failed to find evidence of an association between fixations to the eye region of the face and CA for participants with ASD or TD participants (Klin et al., 2002; Riby & Hancock, 2009a; 2009b; Speer et al., 2007). However, in the present study, there was also a trend towards older children with ASD showing more severe ASD symptomatology ( $r_s = 0.37, p = .11$ ). Thus, participants' age and severity of ASD symptomatology may have interacted to impact on the percentage of time they spent fixated on faces in the current study. A negative relationship between visual fixation patterns to facial stimuli and ASD symptomatology has been established by several previous researchers (Riby & Hancock, 2009a; 2009b). The role of ASD symptomatology is a focus of Chapter 9. The lack of relationship between CA and the duration of fixations to faces or the frequency of attention shifts involving faces for participants with ASD and TD participants is consistent with previous research (Klin et al., 2002; Riby & Hancock, 2009a; 2009b; Speer et al., 2007), as is the failure to find a relationship between orienting to faces and NVIQ (Jones et al., 2008; Norbury et al., 2009; Riby & Hancock, 2009a; 2009b; Speer et al., 2007).

#### *8.4.2.2 Orienting to Objects*

Participants with ASD failed to show the hypothesised preference for objects, relative to TD participants. The hypotheses that participants with ASD would fixate on objects for a higher percentage of time, make more attention shifts between categories of non-facial stimuli, and fixate on objects for longer durations than TD participants were not supported. Both groups of participants spent the majority of their time fixated on objects. They spent a similar percentage of overall time fixated on objects, fixated on objects for a similar duration, and

made a comparable number of attention shifts between objects. However, participants with ASD made significantly more attention shifts per minute between objects and bodies than TD participants. These findings are consistent with several previous researchers, who reported that individuals with ASD did not differ from TD individuals in the time spent looking at objects (Riby & Hancock, 2008; Speer et al., 2007).

Nevertheless, the current findings are inconsistent with other studies reporting that individuals with ASD fixated on objects for a higher percentage of time (Klin et al., 2002) and for longer durations (Swettenham et al., 1998) than TD and DD individuals. Jones et al. (2008) also found that children with ASD showed a trend towards longer fixations to objects than TD children, however, this trend failed to meet their pre-established significance level of .0125. Finally, Werner et al. (2005) reported that infants with ASD showed an increased attention span for objects by 6 months of age. However, as parent report was utilized as a primary means of assessment in this study, these findings may have been influenced by parent's knowledge of their child's diagnosis and related symptomatology.

Considerable heterogeneity in the methodology employed across studies makes it difficult to draw conclusions regarding the exact nature of visual fixation patterns to objects in individuals with ASD. Significant variability in the ratio of objects to social stimuli, the relative salience of objects in the stimuli (e.g., number, size, colour, and contrast), and the complexity of the social stimuli may have considerably influenced results. Thus, the discrepancies between the current findings and studies reporting longer fixations to objects in children with ASD may reflect differences in the specific properties of the stimuli used.

In contrast to previous research, participants with ASD in the current study failed to show a heightened preference for objects relative to TD participants. However, both children with ASD and TD children in the current study spent considerably more time fixated on objects (ASD = 85.79%; TD = 87.32%) than the fixation times to objects reported in previous studies (e.g., Klin et al., 2002: ASD = 9.6%; TD = 3.7%; Jones et al., 2008: ASD = 13.9%; TD = 9.1%). The lack of group differences in the time spent fixated on objects in the current study may therefore reflect the aforementioned salience of objects for both ASD and TD children in

this setting; possibly resulting from their natural curiosity and interest in playing with toys, relative to viewing pictures or movies.

However, in studies where individuals with ASD showed a heightened preference for objects, relative to TD individuals, the social elements of the stimuli were more complex (e.g., more people; people engaged in social interaction) than the social context utilized in the current study. Thus, it is possible that when the social complexity of the stimuli increase or are more salient than the non-social elements of the setting, TD children increase their attention to the social aspects of the stimuli. In contrast, individuals with ASD either fail to regulate and modify (i.e., increase or decrease) their attention according to the most salient stimuli for the context or situation, or increase attention to less-complex non-social aspects of the stimuli when faced with socially complex stimuli. The role of attention modulation in the visual fixation patterns of children with ASD and TD children will be discussed in Chapter 10, Section 10.2.

An examination of the relationships between visual fixation patterns to objects and CA and NVIQ revealed that there were no statistically significant relationships between the percentage of time fixated on objects, the duration of visual fixations to objects, or attention shifts involving objects and CA or NVIQ for participants with ASD. This is consistent with previous research (Klin et al., 2002). However, for TD participants, there was a positive, statistically significant relationship between the average duration of fixations to objects and CA. Older participants fixated on objects for longer durations than their younger counterparts. This is consistent with the present finding that older TD children tended to shift their attention less frequently than younger participants, and may be accounted for by developmental changes in the ability of TD children to sustain their attention to a play activity (Johnson & Ershler, 1981). The failure to find other, statistically significant relationships between orienting to objects and CA or NVIQ for TD participants is consistent with previous research (Klin et al., 2002).

#### 8.4.2.3 *Orienting to Bodies*

The results partially supported the hypothesis that participants with ASD would show a preference for fixating on bodies relative to TD participants. The hypotheses that participants with ASD would fixate on bodies for a significantly higher percentage of overall time, and make more attention shifts between categories of stimuli involving bodies relative to TD participants were supported. Despite this, the hypothesis that participants with ASD would fixate on bodies for significantly longer durations than TD participants was not supported. There was no significant group difference in the mean duration of fixations to bodies for participants with ASD and TD participants.

The finding of increased orienting to bodies in individuals with ASD was supported by previous studies demonstrating that individuals with ASD fixated on bodies for a higher percentage of time than TD individuals (Klin et al., 2002; Riby et al., 2009a; Speer et al., 2007). However, other studies found no evidence of increased orienting to bodies (Jones et al., 2008; Riby & Hancock, 2008).

Relative to previous research, participants with ASD in the current study spent a very small proportion of time fixated on bodies. They fixated on bodies for a much lower percentage of time (ASD = .56%; TD = .13%) than Klin et al. (2002; ASD = 24.6%; TD = 9.7%), and for significantly shorter durations (ASD,  $M = .47$  seconds; TD,  $M = .27$  seconds) than Speer et al. (2007; ASD,  $M = 2.32$  seconds; TD,  $M = 1.31$  seconds). It is therefore possible that the finding of increased fixations to the body region in the present study reflected the relative absence of this behaviour in TD participants, rather than the salience of bodies for participants with ASD. The lower proportion of time spent fixated on bodies in the current study, relative to previous research, may be related to heightened interest in the toys utilized, as previously described. Additionally, it may suggest that when viewing more socially complex stimuli (as utilized by Klin et al., 2002; Speer et al., 2007) children with ASD tend to increase their attention to less-complex elements of the social stimuli (e.g., bodies) in order to facilitate their understanding of the social situation. This issue will be further discussed in Chapter 10, Section 10.2.

Analyses of the relationships between orienting to bodies and the participant characteristics of CA and NVIQ, revealed that there were no statistically significant relationships between the percentage of time fixated on bodies, the duration of fixations to bodies, or attention shifts involving bodies for participants with ASD. This is consistent with previous research (Klin et al., 2002; Speer et al., 2007). However, TD participants who obtained lower NVIQ scores tended to spend more time fixated on bodies than those who achieved higher NVIQ scores. There were no other statistically significant relationships between fixations to bodies and CA or NVIQ for these participants. As no previous research examining the relationship between fixations to bodies and cognitive ability for TD children has been located, these findings may be fortuitous and require replication.

#### *8.4.2.4 Time Unfocused*

The results supported the hypothesis that participants with ASD would spend more time unfocused than TD participants. Children with ASD spent a higher percentage of overall time unfocused, and remained unfocused for longer average durations than TD children. These findings are inconsistent with Swettenham et al. (1998), who reported that participants with ASD did not differ from TD participants in the percentage of overall time, or duration of ‘unfocused’ looking. However, discrepancies in the findings of Swettenham et al. and the current study may relate to differences in the way that ‘unfocused’ looking was defined and scored. In the current study, ‘unfocused’ looking was defined as periods of time where child’s eyes were not fixated on a face, body or object, and there were no observable eye or head movements. However, Swettenham et al. defined ‘unfocused’ looking as periods where the child was neither looking at an object or a person’s face. It included periods of time where the child was physically moving across the room, moving his / her eyes from one stimulus to another, and although not explicitly stated, possibly included the time spent fixated on bodies.

More recently, Klin et al. (2002) reported that children with ASD made more off-screen fixations than other groups, possibly supporting the notion of increased unfocused or ‘off-task’ behaviour in these participants. As it is unclear whether the ‘off-screen fixations’ reported by Klin et al. reflected unfocused attention as in the current study, or whether the child

was looking towards something of interest in their environment, further research is needed to confirm or refute the notion of increased unfocused behaviour in individuals with ASD. Nevertheless the time spent unfocused was small for children with ASD, and group differences may also reflect the relative absence of this behaviour for TD children.

Finally, analyses of the relationships between time unfocused and CA and NVIQ revealed that children with ASD who spent a higher percentage of overall time unfocused and were unfocused for longer durations obtained lower IQ scores. There were no statistically significant relationships between the time spent unfocused and CA and NVIQ for TD children. As no previous research examining the relationship between the time spent unfocused and CA and NVIQ has been located, additional research is needed to confirm or refute these findings.

#### *8.4.2.5 Within-Group Patterns of Orienting Attention*

The results of the current study demonstrated that, overall, the distribution of attention between faces and non-facial stimuli was very similar for participants with ASD and TD participants. Both groups spent a higher percentage of time fixated on objects than faces, bodies or unfocused. They also spent a higher percentage of time fixated on faces than bodies or unfocused. These findings are partially consistent with Swettenham et al. (1998) who reported that TD, DD and ASD children spent more time looking at objects than at people or unfocused. However, in contrast to the current findings, Swettenham et al. reported that participants with ASD spent a higher percentage of time unfocused than looking at faces. The current findings are also inconsistent with Jones et al. (2008) and Klin et al. (2002) who reported that TD, DD and ASD children spent more time fixated on the eye or mouth region of the face than bodies or objects; spending less time fixated on objects than any other type of stimulus.

Analyses of the distribution of attention shifts between faces and non-facial stimuli showed that participants with ASD and TD participants shifted their attention between objects (object ↔ object) and faces and objects (face ↔ object) significantly more frequently than any other category of attention shift. However, while TD participants shifted their attention more frequently between faces (face ↔ face) than between faces and bodies (face ↔ body), and

objects and bodies (object ↔ body), participants with ASD did not differ in the mean frequency of their attention shifts between faces (face ↔ face), faces and bodies (face ↔ body), and objects and bodies (object ↔ body). These findings are partially consistent with Swettenham et al. (1998) who reported that while TD and DD children shifted attention between objects and faces more frequently than any other category of attention shift, participants with ASD shifted attention more frequently between objects than between objects and people, and people and people.

The results of the current study indicated that participants with ASD and TD participants fixated on objects for longer average durations than any other category of stimuli. Additionally, both groups of participants fixated on faces for significantly longer durations than bodies. However, while TD participants fixated on faces for significantly longer durations than they were unfocused, participants with ASD did not differ in the mean duration of time spent fixated on faces or unfocused. These findings are partially consistent with Swettenham et al. (1998) who reported that children with ASD, DD and TD children fixated on people's faces for shorter durations than they fixated on objects, or were unfocused. Swettenham et al. further reported there were no differences in the duration of fixations to people or the time spent unfocused for these participants.

The discrepancies between the current findings and those of Swettenham et al. (1998) may be accounted for by differences in the age of participants and subsequent developmental differences in the orienting behaviour of toddlers and preschool children with ASD. Additionally, the scoring criteria for an 'unfocused' classification employed by Swettenham et al. was significantly different to the criteria employed in the current study (see Chapter 7, Section 7.3.4) and likely inflated the time spent unfocused for their participants. The discrepancies between the current findings and those of Jones et al. (2008) and Klin et al. (2002) may be accounted for by the aforementioned differences in the stimuli used. Featuring social stimuli (e.g., the faces of the actors) and minimizing the non-social aspects of the scene (e.g., background objects) may have decreased the extent to which participants with ASD oriented to objects relative to faces in these studies. Additionally, as previously mentioned, the

different distribution of attention observed in the current study may reflect differences in what both children with ASD and TD children look at, and how long they look at it for, when playing with toys as opposed to viewing stimuli presented on a computer screen.

## 8.5 Chapter Summary and Conclusions

This chapter presented the statistical analyses examining group differences in orienting attention to faces and non-facial stimuli. The relationships between the attention variables and the participant characteristics of CA and NVIQ were then analysed to determine whether these variables differentially impacted on attention for children with ASD and TD children. Overall, the current findings suggest that children with ASD show very similar patterns of attention to TD children when engaged in free-play with toys in a semi-naturalistic setting. Consistent with previous research, there were few group differences in the overall frequency with which children shifted their attention, or in the distribution of their attention between faces and non-facial stimuli in this setting (Fletcher-Watson et al., 2008; Speer et al., 2007; Van der Geest et al., 2001). Nevertheless, children with ASD spent more time looking at bodies and unfocused than TD children (Klin et al., 2002; Speer et al., 2007), and spent significantly less time attending to socially relevant stimuli (i.e., faces) in a more naturalistic, complex, social setting with peers (Clifford et al., 2007; Maestro et al., 2005). When considered with previous research, the current findings suggest that the extent to which children with ASD exhibit impaired social orienting may be strongly influenced by the complexity of the social stimuli to be viewed (Speer et al., 2007), the presence of cues to shift attention (Bowler, 2007), and the child's level of interest or engagement in the stimuli.



## CHAPTER 9: SOCIAL FUNCTIONING, ASD SYMPTOMATOLOGY, AND ORIENTING ATTENTION TO FACES AND NON-FACIAL STIMULI

### 9.1 Chapter Overview

This chapter examines the relationships between social functioning, the severity of ASD symptomatology, and orienting attention to faces and non-facial stimuli for participants with ASD and TD participants. There were four Aims. Aim 3 examined the relationships between social functioning and orienting to faces and non-facial stimuli in the semi-naturalistic setting. Aim 4 examined the relationship between social functioning and orientating to peers' faces in the naturalistic social setting. For all attention variables that were significantly correlated with social functioning in Aim 3 and Aim 4, exploratory correlational analyses were conducted between the significant attention variables and the individual components of the social functioning score (positive social behaviour, play skills, SSRS-T score, and ToM). Aim 5 examined the relationships between the severity of ASD symptomatology and orienting to faces and non-facial stimuli in the semi-naturalistic setting. Aim 6 examined the relationship between the severity of ASD symptomatology and orientating to peers' faces in the naturalistic social setting. In order to determine whether the relationships between orienting to faces and non-facial stimuli, and social functioning and ASD severity and were influenced by language skills, the relationships between the attention variables that were significantly related to social functioning and ASD symptomatology in Aims 3 to 6 and receptive and expressive language skills, were then examined. Finally, in order to ascertain whether the child's level of social functioning may have been influenced by CA, NVIQ, receptive language, or expressive language, the relationships between social functioning, the four variables from which the social functioning variable was comprised (positive social behaviour, play skills, ToM and SSRS-T score), and CA, NVIQ, receptive language, and expressive language were examined.

The findings for each Aim are presented separately, and organized by hypothesis. Data for all Aims were analysed using Spearman's  $\rho$  ( $r_s$ ). Spearman's  $\rho$  and  $p$ -values are presented for each hypothesis in the text.

## 9.2 Relationships Between Social Functioning and Attention to Faces and Non-Facial Stimuli

### 9.2.1 Statistical Analyses for Aim 3

Aim 3 was to examine the relationships between social functioning and orienting to faces and non-facial stimuli in the semi-naturalistic setting. There were three hypotheses. For hypothesis 4, the relationship between social functioning and the mean number of attention shifts per minute was analysed. For hypothesis 5(i), the relationships between social functioning and the percentage of time fixated on faces and non-facial stimuli were analysed. For hypothesis 5(ii), the relationships between social functioning and the frequency of attention shifts between faces and categories of non-facial stimuli were analysed. For hypothesis 5(iii), the relationships between social functioning and the mean duration of fixations to faces and non-facial stimuli were analysed. Social functioning was operationalised as play skills and positive social behaviour with TD peers in the naturalistic social setting, teacher ratings of the child's social behaviour, and ToM.

#### 9.2.1.1 Hypothesis 4: Social Functioning and Attention Shifts per Minute

The following analyses examined the relationships between social functioning and the mean number of attention shifts per minute for children with ASD and TD children. It was hypothesised that there would be a positive correlation between social functioning and the mean number of attention shifts per minute for both groups of participants.

Participants with ASD who obtained higher social functioning scores made somewhat more attention shifts per minute. This relationship showed a positive trend, however, it did not achieve statistical significance,  $r_s = .39$ ,  $p = .09$ .

TD participants who made more attention shifts per minute showed a trend towards lower, not higher, social functioning scores. This negative trend was not statistically significant ( $r_s = -0.45$ ,  $p = .05$ ), and in the opposite direction of prediction.

#### 9.2.1.2 Hypothesis 5(i): Social Functioning and Percentage of Time Fixated on Faces and Non-Facial Stimuli

The following analyses examined the relationships between social functioning and the distribution of attention between faces and non-facial stimuli for ASD and TD participants. It

was predicted that a higher percentage of time fixated on faces would be positively correlated with social functioning, while a higher percentage of time fixated on non-facial stimuli (bodies, objects, or unfocused) would be negatively correlated with social functioning for both groups of children.

Participants with ASD who spent a higher percentage of time fixated on faces, obtained higher social functioning scores. This moderately strong, positive relationship was statistically significant,  $r_s = .52, p = .02$ . Exploratory correlational analyses examining the relationships between the percentage of time fixated on faces, and the individual components of the social functioning score, revealed that there was a moderately strong, positive relationship between the percentage of time fixated on faces, and play scores,  $r_s = .56, p = .01$ . The positive relationship between the percentage of time fixated on faces and positive social behaviour scores approached, however, failed to reach statistical significance,  $r_s = .45, p = .05$ . There was no statistically significant correlation between the percentage of time fixated on faces and SSRS-T ( $r_s = .16, p = .50$ ) or ToM ( $r_s = .16, p = .51$ ) scores for these participants.

Participants with ASD who spent a higher percentage of time unfocused, also obtained lower social functioning scores. This moderately strong, negative relationship was statistically significant,  $r_s = -.54, p = .01$ . Further analyses examining the relationships between the percentage of time unfocused, and the individual components of the social functioning score for participants with ASD, revealed that there was a moderately strong, negative relationship between the percentage of time spent unfocused, and play scores,  $r_s = -.63, p = .003$ . The percentage of time spent unfocused also showed a fair, negative relationship with positive social behaviour scores,  $r_s = -.46, p = .04$ . There was no statistically significant correlation between the percentage of time unfocused and SSRS-T ( $r_s = -.09, p = .70$ ) or ToM ( $r_s = -.21, p = .37$ ) scores for these participants. For participants with ASD, there was no statistically significant correlation between social functioning and the percentage of time fixated on objects ( $r_s = -.16, p = .49$ ) or bodies,  $r_s = .38, p = .10$ .

TD participants who spent a higher percentage of time fixated on bodies obtained somewhat lower social functioning scores. While this relationship showed a negative trend, it

did not achieve statistical significance,  $r_s = -.43, p = .07$ . There was no positive, statistically significant correlation between social functioning and the percentage of time fixated on faces ( $r_s = .12, p = .64$ ), nor was there a negative, statistically significant relationship between social functioning and the percentage of time fixated on objects ( $r_s = -.06, p = .81$ ) or unfocused ( $r_s = -.35, p = .14$ ) for these participants.

#### *9.2.1.3 Hypothesis 5(ii): Social Functioning and Attention Shifts Between Faces and Categories of Non-Facial Stimuli*

The following analyses examined the relationships between social functioning and the distribution of attention shifts between faces and categories of non-facial stimuli. It was hypothesised that a higher number of attention shifts per minute between faces (i.e., face ↔ face) and faces and non-facial stimuli (i.e., face ↔ object, face ↔ body) would be positively correlated with social functioning, while a higher number of attention shifts between categories of non-facial stimuli (object ↔ object, object ↔ body) would be negatively correlated with social functioning scores for participants with ASD and TD participants.

Participants with ASD who made more attention shifts per minute between faces and objects, obtained higher social functioning scores. This moderately strong, positive relationship was statistically significant,  $r_s = .52, p = .02$ . Exploratory correlational analyses examining the relationships between the mean number of attention shifts per minute between faces and objects, and the individual components of the social functioning score for participants with ASD, revealed that there was a trend towards a positive relationship for the mean number of attention shifts per minute between faces and objects, and play scores ( $r_s = .42, p = .07$ ), and positive social behaviour scores ( $r_s = .42, p = .07$ ). There was no statistically significant correlation between the mean number of attention shifts per minute between faces and objects, and ToM ( $r_s = .23, p = .33$ ), or SSRS-T scores,  $r_s = .15, p = .53$ .

Participants with ASD who made more attention shifts per minute between faces and bodies, also achieved higher social functioning scores. This moderately strong, positive relationship was statistically significant,  $r_s = .62, p = .003$ . Further analyses examining the relationships between the mean number of attention shifts per minute between faces and bodies,

and the individual components of the social functioning score for these participants, revealed that there was a moderately strong, positive relationship between the mean number of attention shifts per minute between faces and bodies, and play skills,  $r_s = .57, p = .01$ . There was also a fair, positive relationship between the mean number of attention shifts per minute between faces and bodies, and positive social behaviour scores,  $r_s = .49, p = .03$ . There was no statistically significant relationship between the mean number of attention shifts per minute between faces and bodies, and ToM ( $r_s = .36, p = .12$ ), or SSRS-T scores,  $r_s = .19, p = .43$ .

Participants with ASD who made more attention shifts per minute between objects and bodies, obtained higher, not lower social functioning scores. This, fair, positive relationship was statistically significant and in the opposite direction of prediction,  $r_s = .46, p = .04$ . Analyses examining the relationships between the mean number of attention shifts per minute between objects and bodies, and the individual components of the social functioning score, revealed that there was a moderately strong, positive relationship between the mean number of attention shifts per minute between objects and bodies, and ToM scores,  $r_s = .57, p = .01$ . There was no statistically significant correlation between the mean number of attention shifts per minute between objects and bodies, and SSRS-T scores ( $r_s = .01, p = .97$ ), positive social behaviour scores ( $r_s = .22, p = .36$ ), or play scores ( $r_s = .20, p = .41$ ), for these participants.

For participants with ASD, there was no positive, statistically significant correlation between social functioning and the mean number of attention shifts per minute between faces, ( $r_s = .30, p = .21$ ), and no negative, statistically significant relationship between social functioning and the mean number of attention shifts per minute between objects,  $r_s = -.20, p = .39$ .

TD children, who made more attention shifts per minute between objects, obtained lower social functioning scores. This moderately strong, negative relationship was statistically significant,  $r_s = -.69, p = .001$ . Further analyses examining the relationships between the mean number of attention shifts per minute between objects, and the individual components of the social functioning score revealed that there was a moderately strong, negative correlation between the mean number of attention shifts per minute between objects and SSRS-T scores,

( $r_s = -.56, p = .01$ ), play scores ( $r_s = -.55, p = .02$ ), and positive social behaviour scores, ( $r_s = -.51, p = .03$ ). The negative relationship between the mean number of attention shifts per minute between objects, and ToM approached, however, was not significant,  $r_s = -.44, p = .06$ .

For TD children, there was no positive, statistically significant relationship between social functioning and the mean number of attention shifts per minute between faces ( $r_s = .26, p = .29$ ), faces and objects ( $r_s = .06, p = .81$ ), and faces and bodies ( $r_s = -.25, p = .31$ ); and no negative, statistically significant relationship between social functioning and the mean number of attention shifts per minute between objects and bodies,  $r_s = -.31, p = .19$ .

#### *9.2.1.4 Hypothesis 5(iii): Social Functioning and the Duration of Fixations to Faces and Non-Facial Stimuli*

The following analyses examined the relationships between social functioning and the mean duration of fixations to faces and non-facial stimuli. It was hypothesised that higher mean durations of fixations to faces would be positively correlated with social functioning while higher mean durations of fixations to non-facial stimuli (objects, bodies and unfocused) would be negatively correlated with social functioning for participants with ASD and TD participants.

Participants with ASD who were unfocused for longer mean durations obtained somewhat lower social functioning scores. This relationship showed a negative trend but was not significant,  $r_s = -.39, p = .09$ . There was no positive, statistically significant relationship between social functioning and the mean duration of fixations to faces ( $r_s = -.00, p = .99$ ), and no negative, statistically significant relationship between social functioning and the mean duration of fixations to objects ( $r_s = -.22, p = .35$ ) or bodies ( $r_s = .29, p = .21$ ) for these participants.

TD children who spent longer mean durations fixated on objects achieved higher social functioning scores,  $r_s = .64, p = .003$ . This moderately strong, positive relationship was in the opposite direction of prediction. Analyses examining the relationships between the mean duration of fixations to objects and the individual components of the social functioning score showed that there was a moderately strong, positive relationship between the mean duration of fixations to objects, and ToM scores,  $r_s = .58, p = .01$ . There was no statistically significant

correlation between the mean duration of fixations to objects and play scores ( $r_s = .38, p = .11$ ), SSRS-T scores ( $r_s = .36, p = .13$ ), or positive social behaviour scores ( $r_s = .17, p = .49$ ).

TD children who fixated on bodies for longer mean durations obtained somewhat lower social functioning scores. While this relationship showed a negative trend, it was not significant,  $r_s = -.43, p = .07$ . There were no statistically significant relationships between social functioning and the mean duration of time unfocused ( $r_s = -.34, p = .16$ ) or the mean duration of fixations to faces, ( $r_s = 0.26, p = .28$ ) for these participants.

#### *9.2.1.5 Summary for Aim 3*

These analyses examined the relationships between social functioning and orienting to faces and non-facial stimuli for participants with ASD and TD participants. Refer to Table 5 for a summary of the relationships between the attention variables and social functioning, and the individual components of the social functioning score.

Children with ASD who obtained higher social functioning scores tended to spend more time fixated on faces and shifted their attention more frequently between faces and objects, faces and bodies, and objects and bodies in the semi-naturalistic setting than those who obtained lower social functioning scores. In particular, children with ASD who spent more time fixated on faces obtained higher play scores. Those who made more attention shifts between faces and bodies obtained higher positive social behaviour and play scores, while those who shifted their attention more frequently between objects and bodies obtained higher ToM scores. Finally participants with ASD who spent more time unfocused obtained lower positive social behaviour and play scores.

TD children who made more attention shifts between objects tended to obtain lower social functioning scores, while those who fixated on objects for longer durations tended to obtain higher social functioning scores. Specifically, TD children who made more attention shifts per minute between objects obtained lower positive social behaviour, play and SSRS-T scores. TD children who spent longer average durations fixated on objects obtained higher ToM scores.

Table 5

*Relationships between the attention variables and social functioning and the individual components of the social functioning score for children with ASD and TD children*

Attention Variables	ASD (n = 20)					TD (n = 19)				
	Soc Fxn**	PSB***	Play	ToM****	SSRS-T*	Soc Fxn**	PSB***	Play	ToM****	SSRS-T*
<b>Semi-naturalistic setting:</b>										
Mean attention shifts p/min										
Percentage of time fixated on objects										
Percentage of time fixated on faces	a			a						
Percentage of time fixated on bodies										
Percentage of time unfocused	b	b		b						
Mean shifts face ↔ face p/min										
Mean shifts object ↔ object p/min						b	b	b		b
Mean shifts face ↔ object p/min	a									
Mean shifts face ↔ body p/min	a	a		a						
Mean shifts object ↔ body p/min	a			a						
Mean duration of fixations objects						a			a	
Mean duration of fixations to faces										
Mean duration of fixations to bodies										
Mean duration of time unfocused										
<b>Naturalistic Setting:</b>										
% intervals fixated on peers faces	a	a	a	a		a	a	a		

*Note.* <sup>a</sup> blue represents a positive relationship; <sup>b</sup> yellow represents a negative relationship; \* Social Skills Rating Scale – Teacher version score; \*\* Overall Social Functioning Score; \*\*\*Positive Social Behaviour Score; \*\*\*\* Theory of Mind score



### 9.2.2 Statistical Analyses for Aim 4

Aim 4 was to examine the relationship between social functioning and orienting to peers' faces in the naturalistic social setting. This was operationalised as the mean percentage of intervals participants' made fixations to peers' faces in the naturalistic social setting.

#### 9.2.2.1 Hypothesis 6: Social Functioning and Attention to Faces in the Naturalistic Setting

The following analyses examined the relationships between social functioning and the mean percentage of observation intervals in which participants with ASD and TD participants fixated on peers' faces in the naturalistic setting. It was hypothesised that the percentage of fixations to peers' faces in the naturalistic setting would be positively correlated with social functioning for both groups of participants.

Participants with ASD who fixated on peers' faces for a higher percentage of observation intervals, obtained higher social functioning scores. This very strong, positive relationship was statistically significant,  $r_s = .80, p = .001$ . Further analyses examining the relationships between the percentage of intervals fixated on peers' faces, and the individual components of the social functioning score revealed there was a moderately strong, positive relationship between the percentage of intervals fixated on peers' faces and positive social behaviour scores, ( $r_s = .73, p = .001$ ) and ToM scores ( $r_s = .55, p = .01$ ). The percentage of intervals fixated on peers' faces also showed a fair, positive relationship with play scores, ( $r_s = .46, p = .04$ ) for these participants. There was no statistically significant correlation between the percentage of intervals fixated on peers' faces and SSRS-T scores,  $r_s = .20, p = .39$ .

TD children, who fixated on peers' faces for a higher percentage of observation intervals, also obtained higher social functioning scores. This fair, positive relationship was significant,  $r_s = .48, p = .04$ . Further analyses examining the relationships between the percentage of intervals fixated on peers' faces, and the individual components of the social functioning score, showed a moderately strong, positive relationship between the percentage of intervals fixated on peers' faces, and positive social behaviour scores ( $r_s = .65, p = .003$ ) and

play scores,  $r_s = .66$ ,  $p = .002$ . There was no statistically significant correlation between the percentage of intervals fixated on peers' faces and SSRS-T scores ( $r_s = .18$ ,  $p = .46$ ), or ToM scores ( $r_s = .28$ ,  $p = .24$ ) for these participants.

#### *9.2.2.2 Summary for Aim 4*

These analyses examined the relationships between social functioning, and the mean percentage of observation intervals in which participants with ASD and TD participants fixated on peers' faces in the naturalistic social setting. For both groups of participants, children who fixated on peers' faces on a higher percentage of observation intervals obtained higher social functioning scores. Children with ASD who fixated on peers' faces on a higher percentage of intervals obtained higher positive social behaviour, play and ToM scores. TD children who fixated on peers' faces on a higher percentage of observation intervals obtained higher positive social behaviour and play scores. For participants with ASD, the percentage of intervals fixated on peers' faces in the naturalistic setting had the strongest relationship with social functioning. For TD participants, the mean number of attention shifts per minute between objects was most strongly related to social functioning. Refer to Table 5 for a summary of the relationships between the attention variables and social functioning and the individual components of the social functioning score for children with ASD and TD children.

### 9.3 Relationships between ASD Symptomatology and Attention to Faces and Non-Facial Stimuli

#### *9.3.1 Statistical Analyses for Aim 5*

In Aim 5, exploratory correlational analyses were undertaken to examine the relationships between the severity of ASD symptomatology and orienting to faces and non-facial stimuli for participants with ASD in the semi-naturalistic setting. There were four hypotheses. For hypothesis 7 the relationship between the severity of ASD symptomatology and the mean number of attention shifts per minute was analysed. For hypothesis 8(i), the relationships between the severity of ASD symptomatology and the percentage of time fixated

on faces and non-facial stimuli were analysed. For hypothesis 8(ii) the relationships between the severity of ASD symptomatology and the mean number of attention shifts between faces and categories of non-facial stimuli were analysed. For hypothesis 8(iii), the relationships between the severity of ASD symptomatology and the mean duration of fixations to faces and non-facial stimuli were analysed. The severity of ASD symptomatology was operationalised as the child's SCQ scores, with higher SCQ scores indicative of more severe ASD symptomatology.

#### *9.3.1.1 Hypothesis 7: The Severity of ASD Symptomatology and the Mean Number of Attention Shifts per Minute*

The following analysis examined the relationship between the severity of ASD symptomatology and the mean number of attention shifts per minute for children with ASD. It was hypothesised that there would be a negative correlation between the severity of ASD symptomatology and the mean number of attention shifts per minute.

The results revealed that there was no negative, statistically significant relationship between the severity of ASD symptomatology and the mean number of attention shifts per minute ( $r_s = -.37, p = .11$ ) for these participants.

#### *9.3.1.2 Hypothesis 8(i): The Severity of ASD Symptomatology and Time Fixated on Faces and Non-Facial Stimuli*

The following analyses examined the relationships between the severity of ASD symptomatology and the distribution of attention between faces and non-facial stimuli for participants with ASD. It was predicted that a higher percentage of time fixated on faces would be negatively correlated with the severity of ASD symptomatology, while a higher percentage of time fixated on non-facial stimuli (bodies, objects, or unfocused) would be positively correlated with the severity of ASD symptomatology.

Consistent with predictions, participants with ASD who spent a higher percentage of time fixated on faces, showed lower levels of ASD symptomatology. This moderately strong,

negative relationship was statistically significant ( $r_s = -.60, p = .01$ ). Participants with ASD who spent a higher percentage of time unfocused, also showed significantly higher levels of ASD symptomatology ( $r_s = .54, p = .01$ ). There was no statistically significant relationship between the severity of ASD symptomatology and the percentage of time fixated on objects ( $r_s = .14, p = .55$ ), or bodies,  $r_s = -.13, p = .59$ .

*9.3.1.3 Hypothesis 8(ii): The Severity of ASD Symptomatology and Attention Shifts Between Faces and Categories of Non-Facial Stimuli.*

The following analyses examined the relationships between the severity of ASD symptomatology and the distribution of attention shifts between faces and categories of non-facial stimuli. It was hypothesised that a higher number of attention shifts per minute between faces (i.e., face ↔ face) and faces and non-facial stimuli (i.e., face ↔ object, face ↔ body) would be negatively correlated with the severity of ASD symptomatology, while a higher number of attention shifts between categories of non-facial stimuli (object ↔ object, object ↔ body) would be positively correlated with the severity of ASD symptomatology for participants with ASD.

Participants with ASD who made more attention shifts per minute between faces and objects showed less severe ASD symptomatology. This moderately strong, negative relationship was statistically significant,  $r_s = -.52, p = .02$ . Participants with ASD who made more attention shifts per minute between faces and bodies also showed a trend towards less severe ASD symptomatology that approached significance,  $r_s = -.45, p = .05$ . There was no statistically significant relationship between the severity of ASD symptomatology and the mean number of attention shifts per minute between objects ( $r_s = -.07, p = .77$ ), faces ( $r_s = -.31, p = .19$ ), or objects and bodies ( $r_s = -.19, p = .41$ ) for these participants.

*9.3.1.4 Hypothesis 8(iii): The Severity of ASD Symptomatology and the Mean Duration of Fixations to Faces and Non-Facial Stimuli*

The following analyses examined the relationships between the severity of ASD symptomatology and the mean duration of fixations to faces and non-facial stimuli. It was hypothesised that higher mean durations of fixations to faces would be negatively correlated with the severity of ASD symptomatology, while higher mean durations of fixations to non-facial stimuli (objects, bodies and unfocused) would positively correlated with the severity of ASD symptomatology.

Participants with ASD who were unfocused for longer mean durations showed higher levels of ASD symptomatology. This moderately strong, positive correlation was statistically significant,  $r_s = .55, p = .01$ . Participants with ASD who fixated on faces for longer mean durations also showed somewhat lower levels of ASD symptomatology. This relationship approached statistical significance,  $r_s = -.42, p = .07$ . There was no statistically significant relationship between the severity of ASD symptomatology and the mean duration of fixations to objects ( $r_s = .32, p = .18$ ), or bodies ( $r_s = -.03, p = .92$ ).

*9.3.1.5 Summary for Aim 5*

These analyses examined the relationships between the severity of ASD symptomatology and orienting to faces and non-facial stimuli for participants with ASD in the semi-naturalistic setting. Children with ASD who demonstrated higher levels of ASD symptomatology tended to spend a higher percentage of overall time unfocused, were unfocused for longer durations, spent a lower percentage of overall time fixated on faces, and made fewer attention shifts between faces and objects than participants exhibiting less-severe ASD symptomatology. The percentage of time fixated on faces in the semi-naturalistic setting had the strongest relationship with the severity of ASD-related symptomatology. Refer to Table 6 for a summary of the relationships between the attention variables and the severity of ASD symptomatology for children with ASD.

Table 6

*Relationships between attention variables and the severity of ASD symptomatology for children with ASD*

Attention Variables	ASD ( <i>n</i> = 20) Severity of ASD symptomatology
<b>Semi-naturalistic setting:</b>	
Mean attention shifts p/min	
Percentage of time fixated on objects	
Percentage of time fixated on faces	b
Percentage of time fixated on bodies	
Percentage of time unfocused	a
Mean shifts face ↔ face p/min	
Mean shifts object ↔ object p/min	
Mean shifts face ↔ object p/min	b
Mean shifts face ↔ body p/min	
Mean shifts object ↔ body p/min	
Mean duration of fixations to objects	
Mean duration of fixations to faces	
Mean duration of fixations to bodies	
Mean duration of time unfocused	a
<b>Naturalistic Setting:</b>	
Percentage of intervals fixated on peers' faces	

*Note.* <sup>a</sup> blue represents a positive relationship; <sup>b</sup> yellow represents a negative relationship

### 9.3.2 Statistical Analyses for Aim 6

Aim 6 examined the relationship between the severity of ASD symptomatology, and orienting to peers' faces in the naturalistic social setting.

#### 9.3.2.1 Hypothesis 9: The Severity of ASD Symptomatology and Attention to Faces in the Naturalistic Setting

The following analysis examined the relationship between the severity of ASD symptomatology, and the mean percentage of observation intervals in which participants with ASD fixated on peers' faces in the naturalistic setting. It was hypothesised that the percentage of fixations to peers' faces in the naturalistic setting would be negatively correlated with the

severity of ASD symptomatology for these participants. The results revealed that there was no statistically significant relationship between the severity of ASD symptomatology and the mean percentage of observation intervals fixated on peers' faces in the naturalistic setting,  $r_s = -.20$ ,  $p = .40$ . Refer to Table 6 for a summary of the relationships between attention variables and the severity of ASD symptomatology for children with ASD.

#### 9.4 Relationships between Attention Variables and Receptive and Expressive Language Skills

In order to determine whether the observed relationships between the attention variables and social functioning or severity of ASD symptomatology observed in Aims 3 to 6 were influenced by receptive or expressive language skills, correlational analyses between the attention variables that were significantly related to social functioning or the severity of ASD symptomatology, and receptive and expressive language were conducted using Spearman's *rho* ( $r_s$ ).

##### 9.4.1 Participants with ASD

For participants with ASD, the attention variables that were significantly related to social functioning were: the percentage of time fixated on faces, the percentage of time unfocused, the mean number of attention shifts per minute between faces and objects, the mean number of attention shifts per minute between faces and bodies, the mean number of attention shifts per minute between objects and bodies and the percentage of observation intervals fixated on peers' faces. The attention variables that were significantly related to the level of ASD severity were: the percentage of time fixated on faces, the percentage of time unfocused, the mean number of attention shifts per minute between faces and objects, and the mean duration of time unfocused.

The results revealed a moderately strong, positive correlation between the percentage of time fixated on faces and receptive language skills ( $r_s = .64$ ,  $p = .002$ ), and a fair, positive relationship between the percentage of time fixated on faces and expressive language that approached significance,  $r_s = .40$ ,  $p = .09$ .

Similarly, there was a moderately strong positive relationship between the mean number of attention shifts per minute between faces and bodies and receptive language ( $r_s = .59, p = .006$ ), and a fair, positive correlation between the mean number of attention shifts per minute between faces and bodies and expressive language that approached significance,  $r_s = .43, p = .06$ .

The results also revealed moderately strong, positive correlation between the mean number of attention shifts per minute between faces and objects and receptive language skills ( $r_s = .68, p = .001$ ). However, the relationship between the mean number of attention shifts per minute between faces and objects, and expressive language skills was not significant ( $r_s = .38, p = .10$ ).

Analyses of the relationships between the percentage of time unfocused and receptive and expressive language skills, revealed that the percentage of time unfocused showed a fair, negative correlation with expressive language ( $r_s = -.48, p = .03$ ), and a moderately strong, negative correlation with receptive language,  $r_s = -.72, p = .001$ .

Similarly, there was a moderately strong, negative correlation between the mean duration of time unfocused and receptive language ( $r_s = -.65, p = .002$ ), and a fair, negative relationship between the mean duration of time unfocused and expressive language that approached significance,  $r_s = -.42, p = .06$ .

There was no statistically significant relationship between the mean number of attention shifts per minute between objects and bodies and receptive ( $r_s = .23, p = .33$ ) or expressive language skills ( $r_s = .09, p = .71$ ) for these participants.

Finally, analyses of the relationships between the mean percentage of intervals fixated on peers' faces and receptive and expressive language skills, revealed that there was a fair, positive relationship between the mean percentage of intervals fixated on peers' faces and receptive language ( $r_s = .49, p = .03$ ). There was also a fair, positive correlation between the mean percentage of intervals fixated on peers' faces and expressive language, however, this relationship was not significant,  $r_s = .39, p = .09$ .



#### 9.4.2 TD Participants

For TD participants, the attention variables that were significantly related to social functioning were: the mean number of attention shifts per minute between objects, the average duration of fixations to objects, and the percentage of observation intervals fixated on peers' faces.

Analyses of the relationships between the mean number of attention shifts per minute between objects and receptive and expressive language skills revealed that there was a moderately strong, negative correlation between the mean number of attention shifts per minute between objects and receptive ( $r_s = -.52, p = .02$ ) and expressive ( $r_s = -.52, p = .02$ ) language skills.

There was no statistically significant relationship between the mean duration of fixations to objects and receptive ( $r_s = .16, p = .50$ ) or expressive ( $r_s = .07, p = .79$ ) language skills, nor was there a statistically significant relationship between the mean percentage of intervals fixated on peers' faces and receptive ( $r_s = -.02, p = .92$ ) or expressive language skills ( $r_s = -.15, p = .54$ ) for these participants.

#### 9.4.3 Summary

Participants with ASD who obtained higher receptive language scores spent a higher percentage of overall time looking at faces, made more attention shifts per minute between faces and objects and faces and bodies in the semi-naturalistic setting, and fixated on peers' faces on a higher percentage of observation intervals in the naturalistic setting. Those who spent a higher percentage of overall time unfocused, and were unfocused for longer durations, tended to obtain lower receptive language scores. Participants with ASD who spent a higher percentage of overall time unfocused also obtained lower expressive language scores. Finally, TD participants who made more attention shifts per minute between objects tended to obtain lower receptive and expressive language scores. Refer to Table 7 for a summary of the relationships between the attention variables that were significantly related to social functioning and severity of ASD symptomatology, and receptive and expressive language for participants with ASD and TD participants.

Table 7

*Relationships between the attention variables significantly related to social functioning and severity of ASD symptomatology, and receptive and expressive language for ASD and TD participants*

Group	Attention Variables	Receptive Language	Expressive language
ASD	<b>Semi-Naturalistic Setting:</b>		
	Percentage of time fixated on faces	a	
	Percentage of time unfocused	b	b
	Mean shifts face ↔ object p/min	a	
	Mean shifts face ↔ body p/min	a	
	Mean shifts object ↔ body p/min		
	Mean duration of time unfocused	b	
	<b>Naturalistic Setting:</b>		
	Percentage of intervals fixated on peers' faces	a	
	TD	<b>Semi-Naturalistic Setting:</b>	
Mean attention shifts p/min			
Mean shifts object ↔ object p/min		b	b
Mean duration of fixations to objects			
Mean duration of fixations to faces			
<b>Naturalistic Setting:</b>			
Percentage of intervals fixated on peers' faces			

*Note:*<sup>a</sup> blue represents a positive relationship; <sup>b</sup> yellow represents a negative relationship

### 9.5 Relationships between Participant Characteristics and Social Functioning Variables

In order to determine whether participants' social functioning skills may have been influenced by the participant characteristic variables, CA, NVIQ, receptive, and expressive language skills, correlational analyses between social functioning, the variables from which the social functioning score was comprised (positive social behaviour, play skills, SSRS-T scores and ToM) and the aforementioned participant characteristic variables were conducted using Spearman's *rho* ( $r_s$ ).

### 9.5.1 Participants with ASD

For participants with ASD, there was a moderately strong positive correlation between social functioning and receptive ( $r_s = .64, p = .002$ ) and expressive language ( $r_s = .62, p = .003$ ) scores. Analyses of the individual components of the social functioning score (SSRS-T score, ToM, positive social behaviour score, and play skills) revealed that there was a very strong, positive correlation between SSRS-T scores and expressive language,  $r_s = .75, p = .001$ . There were also moderately strong, positive correlations between play skills and NVIQ ( $r_s = .51, p = .02$ ), receptive language ( $r_s = .58, p = .008$ ), and expressive language,  $r_s = .53, p = .02$ . The relationship between SSRS-T scores and CA ( $r_s = -.42, p = .07$ ), SSRS-T scores and receptive language ( $r_s = .44, p = .06$ ), positive social behaviour scores and receptive language ( $r_s = .39, p = .09$ ), and positive social behaviour scores and expressive language ( $r_s = .40, p = .08$ ), approached significance. There were no other statistically significant relationships between the social functioning and participant characteristic variables for participants with ASD.

### 9.5.2 TD Participants

For TD participants, there was a very strong, positive correlation between social functioning and CA,  $r_s = .77, p = .001$ . Further analyses revealed a very strong, positive correlation between ToM scores and CA, ( $r_s = .84, p = .001$ ), and a moderately strong, positive correlation between play skills and CA,  $r_s = .70, p = .001$ . There were no other statistically significant relationships between the social functioning and participant characteristic variables for TD children.

### 9.5.3 Summary

There were a number of significant relationships between social functioning, the variables from which the social functioning score was comprised, and the participant characteristic variables, CA, NVIQ, receptive and expressive language for children with ASD. Participants with ASD who obtained better receptive and expressive language scores tended to score higher on measures of social functioning and play skills. Higher play scores were also obtained by participants with a higher IQ. Finally, participants with ASD who obtained better expressive language scores achieved higher SSRS-T scores. A different pattern of relationships

emerged for TD children, with older TD children obtaining higher social functioning, ToM and play scores. Refer to Table 8 for a summary of the statistically significant relationships between social variables, CA, NVIQ, receptive, and expressive language for ASD and TD participants.

Table 8

*Statistically significant relationships between social variables, CA, NVIQ, receptive, and expressive language for ASD and TD participants*

Group	Social Variable	CA	NVIQ	Receptive Language	Expressive Language
ASD	Social Functioning			a	a
	SSRS-T				a
	ToM				
	Positive Social Behaviour				
	Play		a	a	a
TD	Social Functioning	a			
	SSRS-T				
	ToM	a			
	Positive Social Behaviour				
	Play	a			

*Note.* <sup>a</sup> blue represents a positive relationship

## 9.6 Review and Discussion of Social Functioning, ASD Symptomatology and Attention to Faces and Non-Facial Stimuli

### 9.6.1 Social Functioning, Severity of ASD Symptomatology and General Orienting Ability

The hypotheses that children with ASD who made more overall attention shifts per minute would achieve better social functioning scores and lower ratings of ASD symptomatology were not supported. The lack of statically significant relationships between the mean number of attention shifts per minute and social functioning and ASD symptomatology is inconsistent with previous researchers who theorized that the impairments observed in individuals with

ASD may stem from a general impairment in shifting attention (Bryson et al., 2004a; Courchesne et al., 1994; Elsabbagh et al., 2009; Harris et al., 1999; Kawakubo et al., 2007; Townsend et al., 1999; Zwaigenbaum et al., 2005). However, as stated in Chapter 8, Section 8.4.1, the majority of previous studies utilized computerized paradigms to examine the speed of disengaging and shifting attention in individuals with ASD in response to a cue. In contrast, the current study examined the frequency with which individuals with ASD shift their attention freely between engaging stimuli (i.e., toys). It is therefore possible that relationships between the general orienting ability of individuals with ASD and impairments in social functioning or severity of ASD symptomatology are more strongly to aspects of attention that were not examined in the current study, such as the speed or timing of attention shifts in response to cues to shift attention. This will be further discussed in Chapter 10, Section 10.3.

For TD participants, the hypothesis that children who made more attention shifts per minute would achieve higher social functioning scores was not supported. However, there was a trend towards improved social functioning for TD children who made fewer attention shifts per minute that failed to reach significance ( $p = .05$ ). As no previous research examining the relationship between the frequency of attention shifts per minute and social functioning for TD children was located, these findings require validation. However, the trend towards better social functioning for TD children who made fewer attention shifts may be consistent with the high incidence of social difficulties in children who are impaired in their ability to sustain attention (e.g., those with ADHD; Andrade, Brodeur, Waschbusch, Stewart, & McGee, 2009; Bennett-Murphy, Laurie-Rose, Brinkman, & McNamara, 2007). However, other aspects of social functioning, such as emotion regulation, cognitive and behavioural flexibility have been linked to the ability to rapidly disengage and shift attention (Compton et al., 2004; McConnell & Bryson, 2005). Thus, it is likely that the ability to shift and sustain attention work in tandem to enhance social functioning, with different elements of social behaviour related to different aspects of attention.

### *9.6.2 Relationships between Attention to Faces, Social Functioning and Severity of ASD*

#### *Symptomatology*

For participants with ASD, the results partially supported a relationship between social functioning and orienting to social stimuli (faces). As hypothesised, children with ASD who spent a higher percentage of overall time fixated on faces in the semi-naturalistic setting tended to obtain higher social functioning scores and lower ratings of ASD symptomatology. While children with ASD who fixated on peers' faces on a higher percentage of observation intervals in the naturalistic setting tended to obtain higher social functioning scores as hypothesised, there was no relationship between fixations to peers' faces in the naturalistic setting and severity of ASD symptomatology. The hypotheses that the duration of fixations to faces would be associated with higher ratings of social functioning and lower ratings of ASD symptomatology were not supported. There were no statistically significant relationships between these variables.

Contrary to hypotheses, there was no relationship between the frequency of attention shifts per minute between faces, and social functioning or severity of ASD symptomatology. However, the hypotheses that children with ASD who made more attention shifts per minute between faces and non-facial stimuli (i.e., face ↔ object, face ↔ body) would attain higher social functioning scores were supported. As hypothesised, children who made more attention shifts per minute between faces and objects tended to score lower on measures of ASD symptomatology. There was no relationship between the frequency of attention shifts between faces and bodies and severity of ASD symptomatology.

Further analyses examining the relationships between the attention variables that were significantly correlated with social functioning and the individual components of the social functioning score (positive social behaviour, play skills, ToM and SSRS-T score) revealed that the percentage of time fixated on faces in the semi-naturalistic setting, the mean number of attention shifts per minute between faces and bodies, and the percentage of intervals fixated on peers' faces in the naturalistic setting were positively related to positive social behaviour and

play skills with peers. Children who fixated on peers' faces on a higher percentage of observation intervals were also more likely to achieve higher ToM scores.

The finding that more time spent fixated on faces is related to improved social functioning and lower levels of ASD symptomatology is consistent with previous research (Jones et al., 2008; Riby & Hancock, 2009a; 2009b; Speer et al., 2007). However, a number of these researchers reported that improved social functioning and lower ASD symptomatology were associated with orienting to specific regions of the face. Jones et al. (2008) and Speer et al. (2007) reported that there was an association between longer fixations to the eye region of the face, reduced social impairment, and increased social responsiveness in individuals with ASD. Other researchers failed to find evidence of a relationship between fixations to the eye region and social functioning (Klin et al., 2002; Norbury et al., 2009) or level of ASD symptomatology (Speer et al., 2007); however, they reported that more time fixated on the mouth region of the face was associated with greater social adaption (Klin et al., 2002), less social impairment (Klin et al., 2002) and greater communicative competence (Norbury et al., 2009) in these individuals.

The reasons for the discrepant findings regarding the relationships between fixations to the eye and mouth regions of the face and social functioning and ASD symptomatology are unclear. Small methodological differences in the age and developmental level of participants, the social assessments used, and the method of assessing fixations to faces, appear to produce significantly different findings. However, in studies where relationships between orienting to the eye region and social functioning and ASD symptomatology were reported, the participants were significantly younger than in those studies that failed to find evidence of a relationship between these variables. Although speculative, one possible explanation for this is that, due to the importance of verbal and communication skills for adolescent social interactions, high-functioning adolescents may have learned that they can extract more information and understanding from fixating on the mouth, than the eye region of the face. If this is the case, it likely stems from a learning history fraught with difficulties interpreting information from the eye region, and more success extracting information from the mouth region of the face. The

notion that orienting to the mouth, and not the eye region of the face, can improve communicative competence was highlighted by Norbury et al. (2009), who reported that fixations to the mouth region were associated with improved communicative competence while fixations to the eye region were associated with lower levels of communicative competence for adolescents with ASD.

It is unclear from the methodology employed in the current study whether the relationships between more time spent looking at faces, higher ratings of social functioning, and lower ratings of severity of ASD symptomatology stemmed from orienting to the eye or mouth regions of the face. Further research is needed to determine the exact role of orienting to different regions of the face in the development of social and communicative competence in ASD.

Finally, analyses examining whether the aforementioned relationships between orienting to faces and social functioning and severity of ASD symptomatology were influenced by language abilities, revealed that children with ASD who spent a higher percentage of overall time fixated on faces in the semi-naturalistic setting, made more attention shifts per minute between faces and objects and faces and bodies, and fixated on peers' faces on a higher percentage of observation intervals in the naturalistic setting, tended to obtain better receptive language scores. These findings are inconsistent with previous researchers who failed to find evidence of a relationship between orienting to social stimuli and language skills in children and adolescents with ASD (Jones et al., 2008; Klin et al., 2002; Norbury et al., 2009). However these findings are consistent with Leekam & Ramsden (2006), who established a relationship between higher levels of dyadic orienting and language comprehension and production in children with ASD. Discrepant findings may be related to the stimuli utilized in these studies, with associations between language and orienting to faces reported in studies where participants were viewing real-life faces as opposed to stimuli presented on a computer screen. A relationship between language skills and orienting to real-life faces may be consistent with research demonstrating that TD infants spend more time looking at mouths during periods of language acquisition (Hunnius & Geuze, 2004).



For TD participants, the results partially supported a relationship between social functioning and orienting to socially relevant stimuli (e.g., faces). The hypothesis that TD children who oriented to peers' faces on a higher percentage of observation intervals in the naturalistic setting would obtain higher social functioning scores was supported. The percentage of intervals fixated on peers' faces was most strongly related to positive social behaviour and play skills with peers in the naturalistic setting. However contrary to hypotheses, there were no relationships between social functioning and the percentage of time fixated on faces, the duration of fixations to faces, or attention shifts between faces and non-facial stimuli (i.e., face ↔ object, face ↔ body) in the semi-naturalistic setting for these participants.

As few studies have examined the relationship between orienting attention to faces and social functioning in TD children, these findings require replication. However, the positive relationship between the duration of fixations to the eye region and social functioning is consistent with Speer et al. (2007) who, using a combined group of ASD and TD children, reported that fixations to the eye region significantly predicted social responsiveness.

### *9.6.3 Relationships between Attention to Non-Facial Stimuli (Objects and Bodies), Social Functioning and Severity of ASD Symptomatology*

For participants with ASD, the results failed to support a relationship between social functioning, severity of ASD symptomatology, and orienting to non-facial stimuli (e.g., objects and bodies). The hypotheses that children with ASD who spent a higher percentage of overall time fixated on non-facial stimuli, fixated on non-facial stimuli for longer durations, and who made more attention shifts involving non-facial stimuli (e.g., object ↔ object) would obtain lower social functioning scores and more severe ratings of ASD symptomatology were not supported. However, there was a statistically significant relationship between social functioning and the frequency of attention shifts per minute between objects and bodies in the opposite the direction of prediction. Participants with ASD who made more attention shifts per minute between objects and bodies obtained higher social functioning scores, in particular, ToM scores.

The lack of a statically significant relationship between orienting to objects and social functioning and ASD symptomatology is inconsistent with Klin et al. (2002), who reported that participants with ASD who spent more time fixated on objects exhibited lower levels of social adaptation and higher levels of autistic social impairment. The same trend was observed for the relationship between fixations to bodies and social functioning, however, this relationship failed to achieve statistical significance.

The discrepancy between these and the current findings may be related to differences in the non-social stimuli, age of participants, complexity of the social stimuli utilized, and subsequent differences in the overall visual fixation patterns of individuals with ASD in these two studies. Participants with ASD in Klin et al. (2002) spent considerably more time fixated on objects and bodies, and less time fixated on faces relative to TD participants. Social stimuli were dynamic and complex, and non-social stimuli were common environmental objects that were neither novel nor salient. Thus, for these participants, more time focused on non-social stimuli would likely serve no purposeful function, and instead detract attention from more salient or 'important' environmental stimuli (e.g., social stimuli). As a result, important cues and socially relevant stimuli would be missed, adversely impacting on social functioning. However, in the current study, time spent attending to, and playing with novel, interesting toys is appropriate social behaviour for 3- to 6- year- old children; as evidenced by the similar fixation patterns exhibited by children with ASD and TD children in this setting. Taken together, these findings suggest that the relationship between attention to non-social stimuli and social functioning for individuals with ASD may be dependent on the context, with the environmental salience of the non-social stimuli, relative to the complexity and salience of the social stimuli, significantly impacting on the degree to which attention to non-social stimuli impedes or facilitates social functioning.

However, as no previous research examining the relationships between social functioning and the fixations to non-facial stimuli has been identified, these findings require validation. Similarly, the failure to find a relationship between visual fixation patterns to non-facial stimuli and the severity of ASD symptomatology requires replication.

For TD participants, the results partially supported a relationship between social functioning and orienting to objects; however, this relationship was in the opposite direction of prediction. TD children who spent less time fixated on objects did not obtain higher social functioning scores. Contrary to predictions, TD children who fixated on objects for longer durations and who made fewer attention shifts between objects (object ↔ object) tended to obtain higher social functioning scores. The mean number of attention shifts per minute between objects was the best predictor of social functioning for these participants. Fewer attention shifts between objects per minute was associated with higher play, positive social behaviour, and SSRS-T scores. Longer durations of time fixated on objects was associated with higher ToM scores.

The hypotheses that there would be significant relationships between social functioning, the percentage of overall time fixated on objects and the frequency of attention shifts per minute between objects and bodies were not supported. There were no statistically significant relationships between these variables and social functioning for TD participants. The results also failed to support a relationship between visual fixations to bodies and social functioning for TD participants. The hypotheses that social functioning would be negatively correlated with the percentage of overall time fixated on bodies and the duration of fixations to bodies were not supported.

Finally, there were no statistically significant relationships between the duration of fixations to objects and receptive or expressive language skills; however, children who made fewer attention shifts per minute between objects tended to obtain higher receptive language scores.

As no previous research examining the relationship between social functioning and visual fixation patterns to non-facial stimuli for TD participants has been identified, additional research is needed to confirm or refute the current findings. However, these findings may be consistent with the aforementioned research demonstrating the importance of sustained attention in social interactions with others (Andrade et al., 2009). This issue will be further discussed in Chapter 10, Section 10.3.2.

The significant relationship between more time spent fixated on objects and better social functioning may also be related to the importance of toy-play in the social development of 3-to 6- year-old children. This issue will be further discussed in Chapter 10, Section 10.3.2

#### *9.6.4 Relationships between Time Unfocused, Social Functioning and ASD Symptomatology*

For participants with ASD, the results partially supported a relationship between the time spent unfocused and social functioning. The hypothesis that there would be a negative relationship between the percentage of time unfocused and social functioning was supported. Children with ASD who spent a higher percentage of overall time unfocused tended to achieve more severe ratings of ASD symptomatology and lower social functioning scores; in particular play skills and positive social behaviour scores. The hypothesis that there would be a negative relationship between the duration of time unfocused and social functioning was not supported. There was no statistically significant relationship between these variables for these participants. However, consistent with predictions, children who spent longer durations of time unfocused tended to achieve higher ratings of ASD severity.

Finally, to examine whether the aforementioned relationships between time unfocused and social functioning and severity of ASD symptomatology were influenced by language, the relationships between time spent unfocused, receptive and expressive language skills were examined. The results revealed that children with ASD who spent a higher percentage of overall time unfocused tended to obtain lower receptive and expressive language scores, while those who were unfocused for longer average durations tended to obtain lower receptive language scores. Contrary to hypotheses, there was no relationship between the overall percentage or average duration of time unfocused and social functioning for TD children.

As no previous research examining the relationships between social functioning and the time spent unfocused for either children with ASD or TD children has been located, additional research is needed to confirm or refute the current findings.

## 9.7 Chapter Summary and Conclusions

This chapter examined the relationships between social functioning, the severity of ASD symptomatology, and orienting attention to faces and non-facial stimuli for participants with ASD and TD participants. The results failed to find a relationship between social functioning and the frequency with which children with ASD and TD children shifted their attention between stimuli. While this is inconsistent with previous research (e.g., Courchesne et al., 1994), it may suggest that other aspects of attention that were not examined in the current study, such as the speed or timing of attention shifts, may be important for social functioning for both groups of children. However, as reported in previous research, factors such as the specific stimuli that are attended to (e.g., facial or non-facial), the amount of time spent attending to relevant stimuli, and the ability to shift attention between sources of socially-relevant (i.e., faces) and non-social stimuli were important for social functioning for both groups of children (Jones et al., 2008; Speer et al., 2007).

Children with ASD who achieved higher functioning scores and lower ratings of ASD symptomatology tended to spend more time fixated on faces, less time unfocused, and shifted attention more frequently between faces and objects in the semi-naturalistic setting. They also tended to fixate on peers' faces on a higher percentage of observation intervals in the naturalistic setting. These relationships may have been influenced by language skills, and highlight the importance of orienting to faces in social engagement and pro-social behaviour for children with ASD.

For TD participants, a different pattern of results emerged. Children who made fewer attention shifts per minute between objects, fixated on objects for longer average durations, and fixated on peers' faces on a higher percentage of observation intervals obtained higher social functioning scores. These relationships may have been influenced by CA and cognitive development and possibly highlight the importance of sustained attention in social interactions with others (Andrade et al., 2009).

## CHAPTER 10: OVERALL DISCUSSION AND CONCLUSIONS

### 10.1 Chapter Overview

The final chapter discusses the findings related to the group differences in orienting attention to faces and non-facial stimuli for children with ASD and TD children. Following this, the findings pertaining to the relationships between orienting to faces and non-facial stimuli, and social functioning and ASD symptomatology are discussed. The theoretical and practical implications of the findings are then presented, followed by the methodological and theoretical limitations of the research. Finally, recommendations for future research are outlined.

### 10.2 Group Differences in Attention to Faces and Non-Facial Stimuli

Aim 1 and Aim 2 of this study were to examine whether children with ASD showed a general impairment in orienting attention to all stimuli, or a specific impairment in orienting to social stimuli.

The failure to find group differences in the frequency of overall attention shifts in the present study indicates that individuals with ASD are unimpaired in their ability to shift attention flexibly from one stimulus or location to another, when free to shift and reorient attention in a relatively simplistic setting. When considered with previous research demonstrating that the visuospatial orienting of individuals with ASD is specifically impaired when required to rapidly interpret a cue or cue target relationship (Courchesne et al., 1994; Elsabbagh et al., 2009; Landry & Bryson, 2004), these findings suggest that an impaired ability to shift attention in ASD is secondary to a more primary deficit in the rapid control, coordination and regulation of attentional resources (Pascualvaca et al., 1998). Impairments in the volitional but not the reflexive aspects of attention are consistent with the view that individuals with ASD are more impaired in higher- than lower-order cognitive processes (Minshew et al., 2001). Thus, the extent to which individuals with ASD exhibit visospatial orienting deficits may be dependent on the context, with slower or fewer attention shifts more

likely to be observed in environments containing multiple cues for processing; in which the scope and focus of attention needs to be rapidly altered in response to changes in incoming stimuli.

However the interaction between visuospatial orienting (i.e., the speed and frequency of attention shifts), environmental stimuli (particularly the presence and complexity of cues eliciting volitional attention shifts) and the coordination and regulation of attentional resources are likely to be influenced by the effects of motivation. Posner stated that there is an intentional component to all attention shifts, with environmental stimuli only eliciting a shift of attention if it holds some importance to the child (Posner, 1980). The role of motivation in directing and improving the efficiency of attention shifts has been established in previous research (Engelmann & Pessosa, 2007). Thus, it is likely that the degree to which visual stimuli engage the attention of individuals with ASD significantly impacts on the extent to which they visually explore or shift their attention between stimuli. From one perspective, the failure to find group differences in the frequency of attention shifts per minute in the current study may indicate that participants with ASD were more interested in, and motivated to visually explore the stimuli (i.e., toys, parent and researcher) presented in the current study, relative to configurations presented on a computer screen as in previous studies. However, the notion that individuals with ASD may be impaired in their ability to disengage and shift their attention from highly engaging environmental stimuli indicates that there may be an optimal range of engagement with regards to environmental stimuli for these individuals. Stimuli that fall outside this range as a result of being more or less engaging may result in fewer shifts of attention, due to the child's lack of interest or difficulties disengaging attention. Evidence also suggests that, for individuals with ASD, orienting attention may be influenced by the degree of complexity or novelty of the stimuli to be viewed. Thus, while intact attentional orienting may be observed when viewing more interesting, simplistic, and predictable stimuli as in the current study, highly complex, novel or unpredictable stimuli may result in atypical patterns of attention; characterized by reduced visual attention and / or avoidance of the complex stimuli (Speer et al., 2007).

Previous research has noted that individuals with ASD show different patterns of attention to social and non-social stimuli. In particular, more time spent looking at non-social stimuli and less time looking at social stimuli has been documented (Dawson et al., 1998; 2004; Klin et al., 2002; Speer et al., 2007; Swettenham et al., 1998). An impaired ability to orient to socially relevant stimuli (e.g., faces) has been linked to a lack of social motivation, possibly due to difficulties understanding and assimilating the complex nature of social information. However, in the semi-naturalistic setting in the current study, children with ASD and TD children demonstrated similar visual fixation patterns to social and non-social stimuli. These findings suggest that, at least in relatively simplistic social settings, children with ASD may be unimpaired in their ability to orient to all types of stimuli.

The lack of social orienting impairment observed in children with ASD in the semi-naturalistic setting of the current study may be related to the relative salience of the non-social (i.e., toys) versus social (i.e., faces) stimuli utilized (see Chapter 8, Section 8.4.2). The elevated salience of objects may have created a context in which it was more appropriate for 3- to 6-year-old children to focus on toy play, rather than on their parents or the researcher. Group differences in social orienting behaviour were thus minimized by the low percentage of overall time spent looking at faces for both groups of participants in this setting.

However, despite the low level of social orienting observed for both groups of participants in the semi-naturalistic setting, children with ASD still spent a comparable amount of time fixated on faces relative to TD children. It is possible that the social orienting behaviour of children with ASD was enhanced by prior learning. Children with ASD in the current study participated in intensive early intervention programs based on the principles of Applied Behaviour Analysis (ABA). As a result, they were accustomed to working intensively with parents and adult teachers in a 1:1 setting, and had received some training in establishing eye-contact when engaged in social interactions with others. While the exact role of early-intervention on the development of social orienting behaviour is unclear, it is possible that the ability to orient to faces, at least in a semi-naturalistic context, was a result of explicit learning for these participants. Over time, reward value may have been assigned to orienting to the faces



of both their parents and teachers, further increasing the frequency with which they spontaneously oriented to faces in this setting. The prior learning experienced by children with ASD in the current study may also account for the lack of differences in the distribution of attention between the faces of parents and the researcher. However, the significant social orienting impairment observed for children with ASD in the naturalistic social setting indicates that even when children with ASD do not differ from TD children in the amount of time they spend looking at faces in simplistic social settings, the same capacity for social attention may not necessarily be observed in more complex social settings.

In the current study, the naturalistic setting was characterised by a continuous stream of complex and unpredictable social interactions; with and between peers, during a period of unstructured 'play' in the preschool or school setting. In this setting, social cues were presented fleetingly from multiple modalities. In contrast, in the semi-naturalistic setting, visual fixation patterns were examined in the presence of two adults, one of whom was the child's mother. The adults neither interacted with each other, nor the child, unless the interaction was initiated by the child. The social complexity of each setting may have been further differentiated by the presence of adults or peers in the setting. Previous research has shown that children with ASD are significantly more likely to initiate interaction with adults than peers (Anderson et al., 2004; Huack et al., 1995). Furthermore, while children with ASD and TD children did not differ on the amount of time they spent looking at their parent or the researcher in the semi-naturalistic setting, the extent to which the presence of parents in the semi-naturalistic, but not the naturalistic setting, impacted on their visual fixation patterns is unclear.

The finding of intact social orienting in the semi-naturalistic setting and impaired social orienting in the naturalistic setting for children with ASD supports the notion that it may not be the presence of faces per se, but the complexity of the social situation that increases the degree of social orienting impairment observed in individuals with ASD. It is unclear whether reduced attention to complex and dynamic social stimuli (e.g., faces) is due to an inability to know what aspects of complex stimuli are important to attend to, reflects a reduced ability to notice, and direct attention to relevant social cues before they move and change, or stems from an attempt

to decrease stimulus input and increase understanding. However, the role of social complexity in the severity of the social orienting impairment observed in individuals with ASD is consistent with several other studies demonstrating that these individuals are significantly impaired in social orienting when viewing complex, social stimuli (Klin et al., 2002; Speer et al., 2007). It is also consistent with the notion of impaired preferential attention to biological motion in children with ASD (Klin et al., 2009).

However, it is also possible that impaired social orienting in more complex social settings for individuals with ASD stems from a deficit in the modulation of attention, and an impaired ability to identify and direct attention to the most salient environmental stimuli for the context or situation. While the measures utilized in the current study did not allow for the direct comparison of social orienting in the semi-naturalistic and naturalistic settings, it appears that TD children spent more time fixated on peers' faces in the naturalistic setting than on the faces of their parent or researcher in the semi-naturalistic setting. Contextual-specific differences in the focus of attention for TD children suggests that they are proficient at directing their attention to the most salient environmental stimuli and adjusting the scope of their attention in response to environmental changes. The notion that TD individuals increase their attention to socially relevant stimuli as the social content and complexity of the stimuli increase is supported by previous research (Birmingham, Bischof, & Kingstone, 2008).

However, children with ASD do not appear to adjust the scope of their attention when viewing complex social stimuli to the degree necessary for understanding and integrating these stimuli. The lack of group differences in the distribution of attention in the semi-naturalistic setting indicates that, in this setting, objects and faces had a similar salience for both groups of children. However, when the social complexity of the situation increased (i.e., in the naturalistic social setting), children with ASD spent significantly less time attending to socially salient stimuli relative to TD children. The notion that individuals with ASD spend less time fixated on socially salient stimuli and more time focused on less socially-relevant aspects of the environment when viewing complex social stimuli, relative to other groups, is well documented in previous research (Klin et al., 2002; Norbury et al., 2009). This suggests that complex,

dynamic social stimuli do not hold the salience for individuals with ASD as they do for TD individuals. However, it is unclear whether individuals with ASD fail to automatically adjust the scope of their attention as necessary for integrating and understanding complex social stimuli; increase attention to complex social stimuli, but to a lesser degree than other groups; or actively attend to aspects on the environment that they find more salient or less complex than social stimuli (e.g., objects or bodies). When compared with previous research examining viewing patterns to dynamic social stimuli (e.g., Jones et al., 2009; Klin et al., 2002; Norbury et al., 2009), the time spent fixated on faces in the semi-naturalistic setting of the present study was very low. Thus, it is possible that individuals with ASD increase their attention in response to changes in the salience of social stimuli, however, to a significantly lesser degree than TD children. More research comparing attention to social and non-social stimuli of varying complexity is needed to disentangle these issues, and clearly establish the role of attention modulation in the social attention of individuals with ASD.

When the current findings are considered with previous research, it is also possible that the social complexity of the stimuli impact on the time spent fixated on less complex social stimuli, such as bodies. In the current study, participants with ASD and TD participants demonstrated very similar viewing patterns to bodies in the semi-naturalistic setting. While children with ASD shifted attention to bodies more frequently, and spent more overall time looking at bodies than TD children, the time spent looking at bodies for children with ASD was very low. Group differences may therefore have been inflated by the relative absence of this behaviour in TD children. Both groups of participants fixated on bodies for shorter durations than any other type of stimuli. They also spent considerably less time fixated on bodies than reported in previous research (Klin et al., 2002; Speer et al., 2007). In the majority of previous studies reporting that children with ASD spent considerably more time fixated on bodies, relative to other groups, participants were viewing complex social stimuli (Klin et al., 2002; Speer et al., 2007).

Thus, it is possible that when viewing complex social stimuli, individuals with ASD spend less time fixated on the more dynamic and complex aspects of the stimuli (e.g., faces),

and more time attending to aspects of the stimuli with decreased social complexity (e.g., bodies), relative to other groups. This may represent a strategy to reduce anxiety and decrease excessive quantities of sensory stimuli to be integrated and processed; or may represent a compensatory strategy to understand the social situation by focusing their attention on less complex sources of social information. It may also be related to reduced attention to biological motion (e.g., movement, facial cues, gaze direction) and more attention to aspects of the stimuli with greater audiovisual synchrony (e.g., body movements with associated sounds such as clapping hands, banging on a toy etc). The notion that children with ASD are more attracted to less complex aspects of social stimuli is consistent with research demonstrating that these individuals fixate on mouths and non-feature areas of the face significantly more frequently, and for longer durations than the eye region (Klin et al., 2002; Norbury et al., 2009). It has been hypothesised that human eyes are complex social stimuli, and individuals with ASD preferentially attend to the mouth region of the face due to its high level of audiovisual synchrony (Klin et al., 2002; 2009; Norbury et al., 2009).

However, while the current findings support the notion of impaired orienting to complex, social stimuli in children with ASD, it is unclear whether these findings reflect a specific lack of attention to complex social stimuli, or a more general impairment in orienting attention to all categories of complex social and non-social stimuli. Previous research has demonstrated that individuals with ASD are impaired in their ability to complete complex, higher order cognitive tasks that require the integration and organization of information (Williams et al., 2006b). Thus, the issue of whether individuals with ASD demonstrate impaired social orienting or a more general information processing deficit remains unclear. These issues will be further discussed in Sections 10.5 and 10.6 respectively.

Finally, while children with ASD and TD children demonstrated similar patterns of attention to both social and non-social stimuli in the semi-naturalistic setting, children with ASD spent more time unfocused than TD children. While the overall time spent unfocused was very low, this finding suggests that the immediate environment doesn't capture the attention of some children with ASD to the same extent as other groups. It may also be consistent with the

notion that a high percentage of individuals with ASD display symptomatology consistent with ADHD (e.g., distractibility and inattention; Corbett & Constantine, 2006; Gadow et al., 2004; 2006). Alternatively, these findings may suggest that some of the children with ASD were engaging in some form of unobservable repetitive, ritualistic behaviour that reduced their attention to environmental stimuli. The notion of increased repetitive, ritualistic behaviour in individuals with ASD is well documented in the literature, and would be consistent with the finding that children who spent more time unfocused exhibited higher levels of ASD symptomatology. As these issues were not directly assessed in the current study, they require further consideration in future studies. However, while children with ASD spent more time unfocused than TD children in the present study, their levels of disengagement were very low. They also spent a comparable amount of time fixated on social and non-social stimuli relative to TD children. Thus, the extent to which their unfocused behaviour decreased their overall engagement with environmental stimuli was minimal.

Overall, the current findings indicate that when engaged in free-play with toys in a semi-naturalistic setting, children with ASD show very similar patterns of attention to TD children. There were few group differences in the frequency of attention shifts between stimuli and the distribution of attention between faces and non-facial stimuli. However, more pronounced group differences were observed in lower-level behaviours such as the time spent disengaged from environmental stimuli. Children with ASD also showed significantly less attention to socially relevant stimuli (i.e., peers faces) in a more complex, naturalistic setting. Taken together, these findings suggest that the distribution of attention of children with ASD may be strongly influenced by factors such as the social complexity and degree of interest in the stimuli to be viewed.

### 10.3 Relationships between Attention to Faces and Non-Facial Stimuli, Social Functioning and ASD Symptomatology

Contrary to expectations, there were no statistically significant relationships between the frequency of attention shifts per minute and impaired social functioning or the severity of

ASD symptomatology for children with ASD or TD children. When considered with previous research, these findings suggest that observed relationships between shifting attention and ASD symptomatology or social functioning (e.g., Compton et al., 2004; McConnell & Bryson, 2005; Zwaigenbaum et al., 2005) may be related to other aspects of attention that were not captured by assessing of the frequency of attention shifts per minute, such as the speed and / or timing of attention shifts in response to cues to shift attention. Human interactions are characterized by a constant, rapid, changing, and unpredictable flow of social, emotional, and situational information. The ability to rapidly select information for processing, and shift attention effortlessly across multiple sources of stimuli is critical for understanding, integrating and forming a complete representation of the situation or event. However, the accurate timing and speed of attention shifts in response to changes in incoming stimuli are also of vital importance in establishing mutual connectedness with others, conceptualising the relationships between cues, information, events and outcomes, and benefiting from predictive information or patterns.

The importance of the timing of attention shifts in social development was highlighted by Zwaigenbaum et al. (2005) who reported that slowed disengagement of attention at 12 months of age predicted the degree of social-communicative impairment at 24 months of age. It is also consistent with notion that temporal asynchrony may be related to ASD symptomatology (Boucher, 2003; Kwakye et al., 2011; Wimpory et al., 2002; see Chapter 1, Section 1.10.3). Temporal impairments have been documented in a number of areas of functioning for individuals with ASD, including their social, communication skills (Boucher, 2003; Wimpory et al., 2000), and information processing (Kawakye et al., 2011; Szlag, Kowalska, Galkowski, & Poppel, 2004) skills. However, as the relationships between the speed or timing of attention shifts and social functioning were not a focus of this study, these issues require further consideration in future research.

The results of the current study indicate that, for both children with ASD and TD children, social functioning may be more strongly related to aspects of attention such the ability to shift attention to, and spend time focusing on the most appropriate stimuli for the context (e.g., faces or objects) than the overall frequency of attention shifts as assessed in the present

research. The results further suggest that the aspects of attention that are important for social functioning may differ for children with ASD and TD children.

### *10.3.1 Children with ASD*

For children with ASD, time spent looking at faces in both the naturalistic and semi-naturalistic settings, and shifting attention between people (faces and bodies) and non-facial stimuli (i.e., face ↔ object, face ↔ body, object ↔ body) in the semi-naturalistic setting were related to social functioning. Shifting attention between faces and non-facial stimuli (i.e., face ↔ object, face ↔ body), and spending more time fixated on faces in the semi-naturalistic setting were also related to lower levels of ASD symptomatology. Children with ASD who spent more time unfocused tended to obtain lower social functioning scores.

These findings support the notion that orienting to faces is an important component of social competence for children with ASD. The finding that children who spent more time fixated on faces tended to display better social functioning, suggests that some children with ASD are able to understand and extract meaning from facial cues, and use this information to facilitate social interactions with others. Children who spent more time fixated on faces also tended to show less-severe ASD symptomatology, possibly due to a higher level of social engagement. The finding that fixations to faces was most strongly related to positive social behaviour with peers in the naturalistic setting, highlights the importance of dyadic engagement in successful play interactions with peers, including the ability to initiate and sustain play and conversations, respond to the social bids of others, use non-verbal behaviour (e.g., smiles and gestures) appropriately within the context of reciprocal social interactions, and engage in socially complex forms of play (e.g., cooperative play). These findings are consistent with the relationship between impaired social orienting and the development of play skills reported in previous research (Watson et al., 2003).

The relationship between ToM and orienting to faces in the naturalistic, but not the semi-naturalistic setting, indicates that it may not be orienting to faces per se, but the ability to orient to complex social stimuli (i.e., peers' faces in the naturalistic setting) that is important for the development of social cognition. Several researchers have hypothesised that reduced social

orienting in individuals with ASD may function to decrease the anxiety and confusion experienced in response to difficulties understanding complex, social stimuli (Dawson et al., 2004; Grelotti et al., 2002; Schultz et al., 2000). It is therefore possible that individuals with ASD who spend more time fixated on peers' faces in the natural social setting are more experienced with faces, have better sensory-perceptual skills, and are thus better able to understand and integrate the multifaceted stimuli presented in this context (e.g., eyes, voice modulation, body language, context of social interaction). Mental-state understanding is contingent on the ability to make multiple attributions simultaneously and continuously. It also requires the ability to monitor the rapidly changing elements of the environment or stimuli that inform the attributions (Slaughter & Repacholi, 2003). Thus, experience interpreting and integrating complex social stimuli may underlie the development of ToM understanding. In support of this notion, an association between ToM understanding, information processing and cognitive problem solving has been established in both behavioural and neuroimaging studies (Frith & Frith, 2003; Frith et al., 1994; Kaland et al., 2008a). However, the exact nature of this relationship, and the direction of causality is unclear. It is not known whether the ability to orient to complex social stimuli precedes the development of ToM, or whether an increase in the ability to process complex social stimuli, via an unknown mechanism, leads to simultaneous improvements in orienting to complex social stimuli and ToM understanding. These issues require further examination.

Contrary to expectations, social functioning and ASD symptomatology were not related to the duration of fixations to faces or the frequency of attention shifts between faces in the semi-naturalistic setting. It is possible that the lack of relationship between these variables is due to the context in which social orienting was examined in the current study. Specifically, the adults in the semi-naturalistic setting were not interacting with each other, nor were they interacting with the child, unless initiated by the child. Thus, when shifting attention between unimodal visual stimuli (e.g., people and objects), orienting between faces may be less important. However, a context with dynamic, moving and multimodal stimuli (e.g., people engaged in conversation) may have produced different results, with the ability to shift attention



between people's faces a critical component in navigating and understanding the social situation. Further research is needed to confirm or refute this hypothesis.

The relationships between visual fixation patterns to faces and social functioning and ASD symptomatology were likely to have been influenced by several factors, including the role of social motivation and learning history. Children who spend more time fixated on social stimuli have significantly more opportunities to learn to understand the social cues and nuances that help facilitate social interactions with others. Increased social engagement and the ability to interpret social cues most likely results in more successful social interactions with peers, possibly increasing both the extent to which children with ASD initiate future interactions, and are targeted for social interactions by others.

These relationships may have also been influenced by language skills. In the present study, children who spent more time fixated on faces in the semi-naturalistic and naturalistic settings, and who shifted their attention between faces and non-facial stimuli more frequently in the semi-naturalistic setting, tended to display better receptive language skills. This relationship may have been further influenced by the role of JA in the development of language and social competence. Specifically, the present results support the notion that the ability to shift attention between faces and other environmental stimuli (e.g., objects and bodies) is an important factor in the social behaviour of children with ASD. The ability to orient to faces, and shift attention between faces and non-social environmental stimuli, may underlie the development of JA skills. It is well documented that JA is related to the development of language skills (Luyster et al., 2008; Mundy et al., 2007; Naber et al., 2008; Sigman & Ruskin, 1999; Siller & Sigman, 2008), which are important for social competence (Durkin & Conti-Ramsden, 2007), and are predictive of positive outcome for children with ASD (Baghdadli et al., 2007; Helt et al., 2008; Howlin et al., 2000; 2004). Thus, in the current study, the relationship between orienting to faces and social functioning may have been influenced by receptive language skills; possibly via the role of JA in language development. As JA skills were not assessed in the current study, this interpretation should be validated in future research.

However it is consistent with Dawson et al. (2004), who reported that the relationship between social attention and language was mediated by JA.

The lack of relationships between social functioning and orienting to objects in the current study indicates that when children with ASD are viewing stimuli with relatively low social complexity, and their visual fixation patterns to both social and non-social stimuli are comparable to those of TD children, the presence of non-facial stimuli does not detract from their ability to benefit from the socially meaningful aspects of the environment (i.e., people's faces). However, if attention to non-social aspects of the environment increases when children with ASD are faced with more complex social situations, their ability to benefit from social cues and information may be reduced. Thus, the relationship between social functioning and orienting to objects is likely to be dependent on the social complexity of the environment and the subsequent time children with ASD spend focused on socially relevant stimuli, rather than the presence of non-social stimuli per se.

However, the unexpected finding that the frequency of attention shifts per minute between objects and bodies was positively related to social functioning, suggests that children with ASD who attain better social functioning may show a greater propensity to attend to people and their behaviour, relative to those who are more socially impaired. It also suggests that bodies may hold a special social significance for individuals with ASD. When considered together with the relationship found between social functioning and the frequency of attention shifts per minute between objects and faces, these findings suggest that the ability to shift attention between environmental stimuli and people in general, not just faces, is important for facilitating the social understanding of children with ASD. Orienting to bodies may therefore provide individuals with ASD with "clues" to enhance their understanding of the social situation, when this understanding cannot be facilitated by attending to the more complex eye region of the face. Improvements in social functioning by orienting to the body region may also relate to the importance of perceiving and responding to non-verbal cues (e.g., gestures, pointing, showing, and the use of imitation) in social interactions with others.

It is unclear, however, why attention shifts between object and bodies were more strongly related to social cognition (ToM) than other aspects of social functioning. One possibility is that, when faced with an inability to extract social information from the face region, individuals with ASD who facilitate their social understanding by attending to non-verbal cues and body language show more advanced problem solving skills than those who either direct their attention away from the social stimuli or fail to adapt their strategy to facilitate understanding. A relationship between ToM and cognitive problem solving skills has been established in previous research (Frith & Frith, 2003; Frith et al., 1994; Kaland et al., 2008b).

Finally, the relationship between a higher percentage of time unfocused and lower social functioning scores indicates that participants with ASD who showed a lower level of engagement with their environment demonstrated less positive social behaviour and social play with peers. This suggests that children with ASD who spend more time disengaged from their environment may miss important cues and opportunities for social engagement, subsequently reducing the extent to which they engage in pro-social behaviour and play activities with their peers. The relationship between a higher duration of time spent unfocused and more severe ASD symptomatology supports this relationship; with the parents of children who were unfocused for longer durations reporting that their children exhibited higher levels of repetitive, ritualistic behaviour and poorer social engagement on the SCQ.

### *10.3.2 TD Children*

For TD children, the ability to sustain attention to objects was most strongly related to social functioning. Children who made fewer attention shifts between objects, and who fixated on objects for longer durations, tended to obtain higher social functioning scores. Fewer attention shifts between objects was associated with higher positive social behaviour, play and SSRS-T scores, while longer fixations to objects was associated with higher ToM scores. Taken together, these findings suggest that the ability to sustain attention to a task or activity plays an important role in the social functioning of TD children. The importance of sustained attention in social interactions with others is supported by previous research demonstrating that

the ability to sustain the focus of attention during social games and conversations with peers enhances the child's ability to perceive and interpret important social cues and information necessary for social reciprocity and learning. Children whose ability to sustain attention in their play or social interactions is more poorly developed, exhibit poorer social behaviour and more difficulties' understanding social cognitive concepts (e.g., ToM), than those who demonstrate more focused and sustained attention (Andrade et al., 2009; Bennett-Murphy et al., 2007).

However, is not known whether improvements in social functioning are directly related to the ability to sustain attention to a task or activity, or whether sustained attention represents one aspect of a complex interrelationship between a number of advances in cognitive development at this age. Previous research has shown that significant developments in representational flexibility (Frye et al., 1995; Zelazo et al., 2003), inhibition (Jones et al., 2003), working memory (Lucianna & Nelson, 1998), and language skills (Harris, Rosnay, & Pons, 2006) occur between 3 and 6 years of age in TD children. These cognitive skills are related to advances in play skills, cooperative social behaviour (Dennis, Brotman, Huang, & Gouley, 2007; Durkin & Conti-Ramsden, 2007), and ToM understanding (Carlson et al., 2004; Carlson & Moses, 2001; Pellicano, 2007).

In support of the notion that the relationship between social functioning and fixations to objects may be influenced by age-related cognitive and language developments, a relationship between CA and the duration of fixations to objects and social functioning was established in the current study. Older TD children tended to fixate on objects for longer durations, and displayed better social functioning than younger children. Interestingly, there was no significant relationship between the frequency of attention shifts per minute between objects, and CA in the current study. Instead, the frequency of attention shifts per minute between objects was related to language skills. TD children who made fewer attention shifts per minute between objects tended to exhibit better receptive and expressive language scores.

Another explanation for the relationship between more time focused on objects and social functioning, however, pertains to the importance of play in social development. Due to the salience of toys in the semi-naturalistic setting of the present study, more time focused on

these toys may be indicative of better social and play skills for 3- to- 6- year-old TD children. Play has been linked to a number of areas of development, including cognitive, communicative, language, social, and emotional growth (Holmes & Willoughby, 2005; Toth et al., 2006). Thus, the relationship between the time spent fixated on objects and social functioning may reflect the benefits of sustained and focused play in the social development of TD children.

Another aspect of attention that was related to better social functioning for TD children in the current study, was the percentage of intervals fixated on peers' faces in the naturalistic setting. TD children who fixated on peers' faces on a higher percentage of observation intervals tended to obtain higher social functioning scores. Similarly to children with ASD, fixations to faces was most strongly related to positive social behaviour and play skills with peers; highlighting the importance of dyadic engagement and attuning to socially relevant stimuli (e.g., faces) in successful social engagement with others. However, when considered with the lack of relationship between social functioning and orienting to faces in the semi-naturalistic setting, these findings suggest that the importance of the time spent looking at social stimuli may increase with the complexity of the stimuli to be viewed (Birmingham et al., 2008). By 3 to 6 years of age, TD children may process social stimuli with such proficiency that the extent to which they need to orient to faces in order to integrate and interpret the social stimuli in less-complex social settings is reduced. However, in the complex, naturalistic social setting with peers, they need to spend more time fixated on faces in order to construct social meaning from the dynamic, brief, changing, and sometimes unpredictable social cues presented in this context. The increased importance of orienting to faces in more complex social settings is consistent with research demonstrating that attention to the eye region of the face increases as the social content (e.g., number of people) and social complexity of the social scene increases (Birmingham et al., 2008).

For TD participants, there were no statistically significant relationships between attention to bodies and social functioning, nor was there a relationship between time unfocused and social functioning. This may be due to very low rates of looking at bodies and unfocused behaviour for these children. These findings may reflect the low salience of bodies for TD

children, and the reduced value of bodies as a source of socially relevant information for these children in this context. They also indicate that the overall social functioning of TD children is unlikely to be affected by small periods of time disengaged.

### *10.3.3 Comparison of Children with ASD and TD Children*

A comparison of the relationships between orienting to faces and social functioning for children with ASD and TD children revealed substantially different relationships for these two groups of children. Despite spending equivalent amounts of time fixated to faces in the semi-naturalistic setting, children with ASD who spent more time fixated on faces attained higher social functioning scores. In contrast, there was no relationship between social functioning and the time fixated on faces in the semi-naturalistic setting for TD children. The different relationships between orienting to faces and social functioning may reflect the different levels of social ability and facial processing expertise for these two groups of children. As previously noted, TD individuals are highly efficient and experienced at processing socially relevant stimuli (e.g., faces). They also demonstrate considerably better social functioning than individuals with ASD. Thus, for these children, more or less time fixated on relatively simplistic social stimuli may have little impact on their overall ability to engage in social interactions with others. However, children with ASD are impaired in both social functioning and in the processing of socially-relevant stimuli. As a result, children with ASD who spend more time attending to socially relevant stimuli (e.g., faces) in general, may exhibit better social functioning as a result of having more experience with, and a better understanding of social cues; or they may simply be more socially motivated than those who spend less time fixated on faces. Relationships between social orienting and social functioning are thus more likely to be observed for children with ASD in less-complex social settings than for TD children.

A comparison of the relationships between orienting to non-facial stimuli (objects and bodies) and social functioning for children with ASD and TD children also revealed significantly different relationships between these variables. For TD children, the importance of longer fixations to, and fewer attention shifts between objects, highlights the role of cognitive

development (e.g., sustained attention) in their social skills and cognition. However, for children with ASD, no such relationship was observed. While the reason for this is unclear, it is possible that the interplay between attention, cognitive development and social functioning differs for these two groups of children. Participants with ASD did not differ from TD participants in the duration of their fixations to, or frequency of attention shifts between objects, yet still showed a significant impairment in all areas of social functioning. This indicates that, for these participants, having the same ability to sustain attention to a toy or play activity was not by itself sufficient to develop age-appropriate social behaviour, play skills and ToM. There are a number of potential explanations for this. First, while children with ASD may not differ from TD children in frequency with which they shift or sustain attention, previous research has demonstrated that several areas of cognitive development that underlie the development of social functioning and ToM are absent, impaired or under-developed (delayed) in children with ASD. These include set-shifting (Corbett et al., 2009; Geurts et al., 2004; Verté et al., 2006), working memory (Steele et al., 2007), inhibition (Biro & Russell, 2001; Bishop & Norbury, 2005a; Geurts et al., 2004), and language skills (Tager-Flusberg, 2000a; 2000b). As the relationship between these skills and attention likely underlies the development of social functioning skills and ToM, 'gaps' or impairments in the cognitive development of children with ASD could explain the different pattern of relationships between attention and social functioning relative to TD children. It could also account for the persistent impairment in social functioning despite similarities in the frequency with which these two groups of children sustained or shifted their attention between stimuli.

Second, children will only benefit from the ability to sustain attention if they are attending to the appropriate stimuli for the particular situation or context. The relationship between longer attention to objects and improved social functioning for TD children suggests that these children have a general ability to sustain attention to appropriate social or non-social stimuli as required by the context. However, for children with ASD, the ability to sustain attention is unlikely to improve their overall social functioning if they are not attending to the relevant social cues or interactions for the context; if they not able to maintain their attention to

socially relevant stimuli in more complex settings; or if they fail to adjust both the scope of their attention and the stimulus they are attending to as required.

Finally, the lack of relationship between the time fixated on objects and social functioning for children with ASD may indicate that these children need to spend more time fixated on environmental stimuli than TD children in order to attain the same level of social understanding. This may be due to a reduced ability to understand and interpret the rapidly changing elements of the environment. Additionally, while TD children may integrate multiple sources of stimuli relatively automatically and effortlessly, children with ASD may attain understanding via an alternative cognitive route. In support of this notion, it is well documented that individuals with ASD use cognitive, visual-perceptual or language abilities to overcome deficits in their ability to understand complex social stimuli, and solve explicit social tasks via an alternative, cognitive, route (Kaland et al., 2008; Schultz et al., 2000).

However, another explanation for differences in the relationships between attention to objects and social functioning for TD children and those with ASD pertains to the role of toy play in social development. As previously stated, the present relationship between social functioning and time spent focused on objects for TD children may highlight the importance of toy play in social and communicative development. However, in order to facilitate the development of social and communication skills, toy play would most likely need to be purposeful and appropriate. The failure to find a relationship between attention to objects and social functioning for children with ASD may therefore reflect impoverished play skills in these children, and a lack of the qualities in their play that facilitate social development in TD children. Impaired toy play is well documented in children with ASD (Rowland & Schweigert, 2009; Toth et al., 2006; Williams, 2003). Thus, for these children, the amount of time spent looking at or interacting with toys may be less important than what they are doing with them. However, the specific play activities of participants were not evaluated in the present study. Despite this, it was noted by the researcher that the toy play of some children with ASD was, at times, less purposeful and appropriate than TD children (e.g., less variation in the manipulation



of toys; more combining toys in non-functional and non-symbolic ways), thus lending support to this notion.

#### *10.3.4 Summary*

The results of the current study failed to find a relationship between social functioning and the overall frequency of attention shifts for children with ASD or TD children. However, other aspects of attention such as the specific stimuli that are attended to (e.g., facial or non-facial), the amount of time spent attending to relevant stimuli, and the ability to shift attention between sources of socially-relevant (i.e., faces) and non-social stimuli were important for social functioning. For children with ASD, improved social functioning was related to more time spent fixated on faces in both the semi-naturalistic and naturalistic settings, and frequent attention shifts between socially-relevant and non-social sources of stimuli. These relationships were likely influenced by social motivation, prior learning and language skills, and highlight the importance of orienting to faces in social engagement and pro-social behaviour for children with ASD. For TD children, the importance of sustained attention in social interactions with others was highlighted, possibly stemming from an interrelationship between attention, CA, and cognitive development. While different patterns of relationships were observed for children with ASD and TD children, these findings underscore the importance of attending to contextually-relevant social cues or interactions, maintaining attention to socially relevant stimuli as appropriate, and adjusting both the scope of attention and the stimulus to be attended to in social interactions with others. However, other aspects of attention that were not examined in the current study, such as the speed or timing of attention shifts, may also play a critical role in social functioning for both children with ASD and TD children.

#### 10.4 General Orienting Impairment or Specific Impairment in Orienting Attention to Social Stimuli?

The failure to find group differences in the frequency of attention shifts per minute for participants with ASD and TD participants supports the view that spontaneous basic visual orienting processes are intact in preschool and young school-aged children with ASD when

they are free to shift and reorient attention in a relatively simplistic setting. Furthermore, the lack of a relationship between the frequency of attention shifts per minute and social functioning or the severity of symptomatology for children with ASD fails to support the notion that impairments in ASD stem from diminished input due to an impaired ability to flexibly disengage and shift attention between stimuli. However, the lack of impairment in the frequency with which children with ASD shifted their attention in the current study does not preclude deficits in other areas of general orienting ability that were not assessed in this research, such as the speed or timing of attention shifts.

In contrast, the current findings support the notion of a specific impairment orienting attention to relevant social stimuli in a complex, naturalistic social setting with peers. However, the lack of group differences in orienting to faces in the semi-naturalistic setting indicates that children with ASD may not be universally impaired in orienting to social stimuli, with the degree of impairment related to the social complexity of the stimuli to be viewed.

### 10.5 Implications for the Social Motivation Hypothesis of ASD

The social motivation hypothesis states that individuals with ASD fail to attend preferentially to social stimuli due to impairments in the formation of reward associations for these stimuli (Dawson, Carver et al., 2002; Dawson, Webb, & McPartland, 2005). This results in a cascade of social and neurological deficits that underlie the impairments associated with ASD (Dawson, Carver et al., 2002a; Dawson et al., 2001; Mundy & Neal 2001). The present finding that children with ASD are significantly impaired in orienting to social stimuli in the naturalistic social setting with peers is consistent with this theory. According to this view, impaired social orienting in the naturalistic setting may stem from an inability to simultaneously integrate and interpret the often abstract, dynamic, and variable information that is presented in social interactions with others. This may result in a failure to attribute salience to complex social stimuli, or may lead to the avoidance of such stimuli (Dawson et al., 2004). Relationships observed between the time spent focused on faces, social functioning and ASD

symptomatology in the present study further support the importance of social attention (e.g., to faces) in the normative socialization process.

Recent research suggests that infants later diagnosed with ASD are born with the adaptive reflex to orient attention to faces, particularly the eye region of the face. However, in contrast to TD infants, attention to faces decreases during the first year of life for these infants (Klin, 2010). The consistent finding of impaired social orienting in infants later diagnosed with ASD by the end of the first year of life supports the presence of a social orienting deficit in older infants and toddlers who are later diagnosed with ASD (Clifford et al., 2007; Maestro et al., 2005; Osterling et al., 2002; Swettenham et al., 1998; Werner et al., 2007). However, the present finding of unimpaired social orienting when viewing more simplistic and predictable social stimuli (i.e., in the semi-naturalistic setting), indicates that children with HFASD may exhibit social attention that is comparable to that of TD children in some settings. Some children with HFASD may thus show a protracted developmental trajectory for the acquisition of social orienting skills, and increase their attention to simple social stimuli by 3 to 4 years of age. It is unknown whether the ability to orient to relatively simplistic social stimuli in children with ASD is a learned behaviour (e.g., via early, intensive, behavioural intervention) or develops via an unknown mechanism. However, during the course of development, reward value may be attached to simple forms of social stimuli that are perceived as ‘familiar’ or predictable (such as their parents’ faces), leading to more time spent focused on these categories of social stimuli. As all visual fixations to faces in the current study were spontaneous (i.e., unprompted), it can be inferred that participants’ attended to faces because they held some importance to them (Posner, 1980).

However, the current findings indicate that while children with ASD did not differ from TD children in their visual fixation patterns to faces in the semi naturalistic setting, they were considerably impaired on all measures of social functioning. It is possible that early disruption to the ‘typical’ processes of socialization acquired through attention to social stimuli (e.g., between 12 and 24 months of age) alters the developmental trajectory of children with ASD so profoundly, that later developments in social orienting abilities only partially compensate for

impairments in their social behaviour and understanding. It is also possible that attention to limited categories of social stimuli (e.g., adults' faces), in more simplistic contexts is insufficient to develop social skills and social understanding comparable to those of TD children. Finally, while children with ASD did not differ from TD children in their attention to faces in the semi-naturalistic setting in the present research, the extent to which they process social stimuli at a multi-sensory level, even in simplistic social settings, is unclear. Reduced attention to, and a failure to integrate the numerous visual and auditory stimuli involved in reciprocal social interactions (e.g., facial expression, body language, tone of voice and what is said) would significantly impede social learning and development.

Thus, the relationships between social orienting and social development most likely extend beyond being exposed to social stimuli, or viewing a restricted range of social stimuli. Actively attending to a broad range of social stimuli, seeking out a wide range of social experiences, and extracting meaning from social cues and interactions within a social interactive context is likely to be critical for social development. The importance of motivation in seeking out social experiences and understanding is highlighted by research demonstrating that impairments in social skills and understanding in congenitally blind children may be compensated for by the motivation to actively seek social input (ie., biological motion, sounds, language) from other sensory modalities (Bedny, Pascual-Leone, & Saxe, 2009; Bigelow, 2003; Dale & Salt, 2008; Klin et al., 2009).

#### 10.6 Social Orienting Impairment or a General Impairment in Processing Complex Stimuli?

It is unclear whether the finding that children with ASD show impaired social orienting in the naturalistic but not semi-naturalistic setting represents an impaired ability to orient to complex social stimuli, or a more general impairment in orienting attention to all categories of complex stimuli. As described in Chapter 2, Section 2.4.6, there is mounting evidence to support the notion that individuals with ASD are significantly impaired in their ability to complete complex, higher-order cognitive tasks that require the integration and organization of multiple sources of information (Williams et al., 2006b). Evidence also suggests that social

stimuli are among the most complex forms of stimuli available for perception (O'Connor & Kirk, 2008).

While there is disagreement in the literature regarding the exact nature of the information processing deficit in ASD, the basic premise of these theories is that individuals with ASD are impaired in their ability to assimilate and integrate multiple sources of complex sensory information simultaneously. According to the WCC theory, superior attention to detail without the global context results in an accumulation of details and an impaired ability to understand and interpret the social stimuli presented. Reduced social orienting then results as a means to facilitate understanding, by reducing the amount of information available for processing (O'Connor & Kirk, 2008). Similarly, the EPF theory (Mottron & Burack, 2001; Mottron et al., 2003; see Chapter 2, Section 2.3.4) proposes that an enhanced perception of sensory information presented in social interactions with others leads to confusion and 'sensory overload'. Reduced attention to social stimuli then results as a means to filter out excessive sensory information (O'Connor & Kirk, 2008).

The results of the current study support the notion that children with ASD show the greatest social orienting impairment when viewing more complex social stimuli. However, the extent to which this reflects an impaired ability to integrate multiple sources of social stimuli or an impaired ability to process complex stimuli more generally remains unclear.

### 10.7 Implications for Diagnosis

The finding that children with ASD were significantly impaired in orienting to socially-relevant stimuli (e.g., faces) in the naturalistic, but not the semi-naturalistic setting; and the significant impairment observed in individuals with ASD on all measures of social functioning despite intact social orienting in the semi-naturalistic setting, highlights the disparity in the functioning of individuals with ASD in more simplistic and structured, versus naturalistic settings. As diagnosis typically takes place in the clinical setting, improved functioning in this setting may lead to aspects of the child's symptomatology being misinterpreted or underestimated. The current findings indicate that social attention may be comparable to that of

TD children in the presence of parents and adult clinicians, and atypical patterns of attention and interactions may be reduced in this setting. The notion that manifestations of ASD symptomatology may be significantly less pronounced in structured, than in naturalistic settings, is supported by previous research (Senju et al., 2009). Thus, the assessment of individuals with ASD in a naturalistic social setting with peers or other family members should be considered an important component of the diagnostic process in order to accurately gauge the severity of their social and communicative impairments as they manifest in real world situations.

### 10.8 Implications for Treatment

The results of the current study have a number of important implications for the treatment of individuals with ASD. First, the relationship between orienting to faces and social functioning highlights the importance of teaching children with ASD to orient to socially relevant stimuli (e.g., faces, movement and speech). By pairing attention to salient social stimuli with rewards, children with ASDs' experience of socially relevant stimuli may be altered, and social stimuli may become more rewarding and meaningful for these individuals. An increase in the salience and motivational preference for social stimuli may then facilitate viewing patterns to social and non-social stimuli that are more consistent with those of TD children. The development of later socio-communicative skills that are contingent on the ability to pay attention to others may then be promoted (Dawson, Webb, & McPartland, 2005; Dawson & Zanolli, 2003).

In conjunction with this, explicit training in interpreting information from faces, particularly the eye region of the face, should be a key goal of intervention for individuals with ASD. Improvements in the ability to understand and interpret socially relevant information from these regions will likely make socially relevant stimuli from faces and eyes more predictable, meaningful and rewarding. Increased orienting to faces, and reduced attention to non-socially relevant aspects of the environment may then result.

Third, as individuals with ASD learn to orient to faces in more structured settings, this skill should be actively generalized to naturalistic settings with peers. Both the complexity of the social stimuli, and the number of cues that need to be processed should be systematically increased in order to improve individual with ASDs' ability to orient to more complex forms of social stimuli. To further facilitate their ability to integrate and interpret the changing and unpredictable cues that are characteristic of naturalistic settings, individuals with ASD may benefit from training in non-social complex information processing tasks and in attending to, and responding appropriately to novelty.

Fourth, the results of the current study highlight the importance of teaching individuals with ASD to actively shift their attention between social and non-social sources of information in structured and naturalistic settings. This may facilitate the development of, or increase JA behaviours. Shifting attention between social and non-social stimuli will also help the child to assimilate the different sources of information presented in their environment, and facilitate the formation of an integrated and complete representation of the situation or event.

Finally, improving the child with ASDs' ability to sustain attention to social information is an important intervention target, as highlighted by the reported relationship between sustained attention to objects and social functioning in TD children. The ability to sustain attention during social interactions with peers enhances the child's ability to assimilate and interpret important social cues and information necessary for social reciprocity and learning. In conjunction with this, individuals with ASD should be taught to discriminate between the levels of attention required for processing social situations, and modulate or adjust the scope of their attention accordingly.

As an impaired ability to orient attention to faces likely precedes impairments in JA (Dawson et al., 1998; 2004), social orienting behaviours should be targeted early in life. According to Dawson, Webb, and McPartland (2005), intervention aimed at increasing attention to social stimuli may have differential outcomes for children and adults with ASD. For children with ASD, increased neural plasticity in the developing brain may result in both behavioural and neurological improvements; with improvements in eye-contact, facial

recognition, social responsiveness, and JA skills accompanied by co-occurring changes in brain activation related to facial processing (Dawson, Webb, & McPartland). For adults with ASD, while intervention may produce behavioural improvements in eye-contact and face processing, it may fail to produce related neurological improvements.

## 10.9 Methodological Limitations

There were several potential methodological limitations with the current research. These included limitations pertaining to participant characteristics, the diagnosis of participants with ASD, the assessment protocol, and statistical analyses.

### *10.9.1 Participant Characteristics*

First, all of the participants in the current study had participated in intensive early intervention programs based on the principles of ABA. While the exact role of previous learning in the social orienting behaviour of these participants is unclear, it is possible that explicit training in establishing eye-contact when engaged in social interactions with others increased the frequency with which these participants oriented to faces in the semi-naturalistic setting. However, in other studies that failed to identify social orienting impairments in children and adults with ASD, participants had received no such instruction (Van der Geest et al., 2002). Unimpaired social orienting in certain contexts may thus better reflect the role of specific features of the environment, participant characteristics or development. These issues require further study.

Second, despite 26 to 55 % of individuals with ASD presenting with symptomatology consistent with co morbid ID (Fombone, 2002), the children in the current study were high-functioning, with average to above average cognitive and language abilities. Thus, the extent to which the current findings can be extended to less-able children with ASD is uncertain. It is also unclear whether these findings can be extended to older or younger participants with ASD. Finally, as there was only one participant with a diagnosis of AsD in the current study, it was not possible to compare the social and non-social attention of children with AD and those with AsD.



### *10.9.2 Diagnosis of Participants with ASD*

In recent research, individuals with ASD were typically diagnosed using the ADOS-G (Lord et al., 2000), the ADI-R (Lord et al., 1994) or both. However, participants with ASD were included in the current study if they received a DSM-IV-TR (APA, 2000) diagnosis of AD or AsD from a registered psychologist, and scored above 11 on the SCQ (Rutter et al., 2003). While the ADOS-G (Lord et al., 2000) and ADI-R (Lord, et al., 1994) are the ‘gold standard’ for diagnosis in research, it was beyond the scope of the current study in terms of both funding and resources to utilise these instruments to assess participants.

There are also potential limitations with the use of parent report to assess the severity of ASD symptomatology. While parent report can provide valuable information regarding the type and severity of symptomatology demonstrated by their children, it is also limited by recall biases and inaccuracies regarding ASD symptomatology early in life. Parent report may be further compromised by parents’ knowledge of their child’s diagnosis and subsequent sensitivity to related developmental differences.

### *10.9.3 Assessment Protocol*

In the current study, eye movements were evaluated using 33ms frame-by-frame analysis from video footage, rather than from visual tracking software as utilized in previous research (Jones et al., 2008; Klin et al., 2002; Norbury et al., 2009; Speer et al., 2007). This assessment protocol was considerably less sensitive to small eye movements than visual tracking software, and eye movements were sometimes difficult to judge. However, as eye tracking software does not allow for the measurement of eye movements in more ecologically valid settings, it was not possible to use more precise eye tracking software for the aims and goals of the current study. As moderate to very high inter-rater reliability was obtained (refer to Chapter 7, Section 7.3.4), it could be inferred that the eye movement scores accurately reflected the visual fixation patterns of the participants in the current study.

An additional limitation of the experimental protocol utilized in the study was the presence of adults (in particular the children’s mothers) rather than peers in the semi-naturalistic setting. While the use of adults allowed for the reliable measurement of children’s

eye movements to faces and non-facial stimuli, it is likely that the observed distribution of attention between faces and non-facial stimuli would have differed in the presence of peers. Previous research has demonstrated that individuals with ASD are significantly more likely to initiate interactions with adults than peers (Anderson et al., 2004; Huack et al., 1995). Thus, assumptions regarding the eye movement patterns derived from dyadic interactions with adults in the semi-naturalistic setting employed in this research may not be generalisable to similarly complex settings with peers.

Furthermore, a number of modifications were made to the procedures employed by Swettenham et al. (1998) and Bauminger (2002) to examine social orienting and social behaviour (respectively) in the current research. While these modifications created more clearly defined categories of behaviour, they reduced the extent to which a clear interpretation of the current results could be made in relation to previous research.

Finally, the presence of atypicalities in other areas of attentional, perceptual or visual processing was not examined in the current study. These issues should be an important consideration for future research.

#### *10.9.4 Statistical Analyses*

As the data in the current study violated the normality and homogeneity of variance assumptions for parametric analysis, non-parametric statistics were used. While the use of non-parametric statistics represented a more conservative approach to guard against the inflated risk of type I or type II error, it did not allow for potentially confounding variables, such as CA, NVIQ, and language skills to be statistically controlled for in these analyses. While the role of these variables was examined via separate correlational analyses, firm conclusions could not be made regarding the exact nature of the relationships between these variables and the extent to which they may have impacted on, or mediated the relationships between orienting to faces and non-facial stimuli and social functioning for children with ASD and TD children.

Similarly, as the findings in the current study were based largely on correlational analyses, it is possible that the relationships between these variables were determined by factors other than those examined in the current study, such as previous social skills and attention

training. These factors should be more stringently examined and controlled for in future research.

Finally, due to the large number of correlational analyses conducted in this study, it could be argued that a more conservative threshold for statistical significance (e.g.,  $p < .01$ ) should have been adopted to guard against an inflated risk of Type I error. In the current study, a statistically significant threshold of  $p < .05$  was utilized in order to decrease the risk of missing important group differences or relationships (Type-II error). While significant differences or relationships  $p < .05$  and  $> .01$  should be viewed with caution, the majority of statistically significant findings falling within this range were consistent with previous research, and thus are likely to reflect real group differences or relationships, rather than Type-I error.

#### 10.10 Future Directions

Future research replicating the procedures employed in the present research is needed to confirm or refute the current findings in order to better understand the nature of social / non-social orienting in children with ASD and their relationships with social functioning.

In the current research, the assumptions for parametric analyses were not met and a conservative approach of utilizing non-parametric analyses was adopted (Howell, 2004; Keppel & Wickens, 2004). However there were a number of limitations with the use of non-parametric analysis that are discussed in Section 10.9.4. Future research should aim to address these limitations by employing parametric analyses that reduce the number of comparisons and statistically control for related or potentially confounding variables such as language skills, CA and IQ. For example, the use of multiple regression analysis would be beneficial to identify which attention variables best predict social functioning while controlling for the aforementioned variables (i.e., CA, language and IQ). While the sample size employed in the current research was consistent with other studies of this nature (Osterling et al. 2002; Werner et al. 2000), future researchers should endeavour to recruit a larger sample in order help meet the assumptions underlying these analyses (e.g., normal distribution; homogeneity of variance). However, recent literature suggests that parametric analyses may be utilized even

when the assumptions for parametric analyses are not met (Norman, 2010). Selecting the most appropriate statistical procedures to examine the research questions posed in the current study while addressing the statistical limitations described will be an important goal for future research.

The present study examined participants' ability to orient attention to faces and non-facial stimuli by analysing eye movements obtained in vivo or from video footage in the semi-naturalistic setting. However, an important goal for future research would be to use eye tracking techniques in ecologically valid settings that are more sensitive to minor differences in the speed and timing of visuospatial orienting. This would allow for a more definitive identification of the aspects of orienting attention that are impaired or intact in individuals with ASD, and provide valuable data regarding the timing of eye moments within the context of social interactions with others. Research of this nature would also help to clarify the relationships between visuospatial orienting and social functioning in children with ASD, and determine whether slow or poorly timed attention shifts contribute to the social impairments observed in these individuals.

Future research should also aim to examine the visual fixation patterns of children in ecologically valid settings of both high and low social complexities. This will help to confirm or refute the notion that the social orienting impairment observed in individuals with ASD increases with the complexity of the stimuli to be viewed. Longitudinal research examining the development of attention to social and non-social stimuli across different ages and developmental stages would also enhance our understanding of the development trajectory for these skills in children with ASD. It will also help establish how they may differ from other groups of children at critical points in development.

It is also unclear from the methodology employed in the current study whether the relationships between orienting to faces and social functioning and ASD symptomatology stem from orienting to the eye or mouth region of the face. Previous research has established a relationship between aspects of social and communicative competence and orienting to both the

eye and mouth regions of the face. Further research is needed to understand the exact nature of these relationships and their role in the development of social behaviour in children with ASD.

Another important goal of future research would be to determine whether children with ASDs' impaired ability to orient to social stimuli in the naturalistic social setting stems from difficulties processing complex social stimuli, or a more general impairment in orienting attention to all categories of complex stimuli. Based on the discrepant performance exhibited by individuals with ASD in more structured versus more ecologically valid settings in the present study, an important consideration of research would be to utilize social and non-social stimuli of comparable complexity in an ecologically valid setting. Research examining the ability of children with ASD to process social and non-social stimuli of comparable complexity would significantly enhance our understanding of the processes that lead to reduced social engagement in individuals with ASD.

Finally, while the present study found some support for the notion of reduced social orienting to complex social stimuli in individuals with ASD, it is unclear whether observed group differences were due to a decrease in the social attention of children with ASD, or an increase in attention to social stimuli in more naturalistic settings for TD children. Further research examining whether impaired social orienting to complex stimuli results from impaired social motivation or information processing; or whether it stems from a deficit in attention modulation and subsequent failure to increase attention as the information processing demands of the situation increase is warranted. A better understanding of the role these variables play in children with ASDs' attention to complex social stimuli would not only improve our understanding attentional processes in ASD, but would allow for more targeted intervention.

## 10.11 Conclusions

The current study examined the visual fixation patterns to faces and non-facial stimuli in 3- to 6-year-old children with ASD and TD children. While the distribution of attention was similar for both groups of participants, children with ASD spent more time unfocused and looking at bodies than TD children. An analysis of the relationships between orienting to faces

and non-facial stimuli and social functioning revealed that while orienting to faces was most important for the development of prosocial behaviour and play skills in children with ASD, time spent playing with and attending to objects was most important for TD children. While the relationships established in the current study were not straightforward and were likely influenced by several aspects of cognitive, language and social development, they highlight the importance of social orienting and engagement in the development of prosocial behaviour for young children with ASD.

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## Appendix A

### DSM-IV-TR Diagnostic Criteria for Autistic Disorder, Asperger's Disorder and Pervasive Developmental Disorder - Not Otherwise Specified

Table A1

*Diagnostic Criteria for 299.00 Autistic Disorder*

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299.00 Autistic Disorder
<p>A. Six or more items from (1), (2), and (3), with at least two from (1), and one each from (2) and (3):</p> <ol style="list-style-type: none"><li>1. qualitative impairment in social interaction, as manifested by at least two of the following:<ol style="list-style-type: none"><li>a. marked impairment in the use of multiple nonverbal behaviors such as eye-to-eye gaze, facial expression, body postures, and gestures to regulate social interaction</li><li>b. failure to develop peer relationships appropriate to developmental level</li><li>c. a lack of spontaneous seeking to share enjoyment, interests, or achievements with other people (e.g., by a lack of showing, bringing, or pointing out objects of interest)</li><li>d. lack of social or emotional reciprocity</li></ol></li><li>2. qualitative impairments in communication as manifested by at least one of the following:<ol style="list-style-type: none"><li>a. delay in, or total lack of, the development of spoken language (not accompanied by an attempt to compensate through alternative modes of communication such as gesture or mime)</li><li>b. in individuals with adequate speech, marked impairment in the ability to initiate or sustain a conversation with others</li><li>c. stereotyped and repetitive use of language or idiosyncratic language</li><li>d. lack of varied, spontaneous make-believe play or social imitative play appropriate to developmental level</li></ol></li><li>1. restricted repetitive and stereotyped patterns of behavior, interests, and activities, as manifested by at least one of the following:<ol style="list-style-type: none"><li>a. encompassing preoccupation with one or more stereotyped and restricted patterns of interest that is abnormal either in intensity or focus</li><li>b. apparently inflexible adherence to specific, nonfunctional routines or rituals</li><li>c. stereotyped and repetitive motor manners (e.g., hand or finger flapping or twisting, or complex whole-body movements)</li><li>d. persistent preoccupation with parts of objects</li></ol></li></ol> <p>B. Delays or abnormal functioning in at least one of the following areas, with onset prior to age 3 years: (1) social interaction, (2) language as used in social communication, or (3) symbolic or imaginative play.</p> <p>C. The disturbance is not better accounted for by Rett's Disorder or Childhood Disintegrative Disorder.</p>

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Table A2

*Diagnostic Criteria for 299.80 Asperger's Disorder*

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299.80 Asperger's Disorder
A. Qualitative impairment in social interaction, as manifested by at least two of the following: <ol style="list-style-type: none"><li>1. marked impairment in the use of multiple nonverbal behaviours such as eye-to-eye gaze, facial expression, body postures, and gestures to regulate social interaction</li><li>2. failure to develop peer relationships appropriate to developmental level</li><li>3. a lack of spontaneous seeking to share enjoyment, interests, or achievements with other people (e.g., by a lack of showing, bringing or pointing out objects of interest to other people)</li><li>4. lack of social or emotional reciprocity</li></ol>
B. Restricted repetitive and stereotyped patterns of behaviour, interests, and activities, as manifested by at least one of the following: <ol style="list-style-type: none"><li>1. encompassing preoccupation with one or more stereotyped and restricted patterns of interest that is abnormal either in intensity or focus</li><li>2. apparently inflexible adherence to specific, non functional routines or rituals</li><li>3. stereotyped and repetitive motor mannerisms (e.g., hand or finger flapping or twisting, or complex whole-body movements)</li><li>4. persistent preoccupation with parts of objects</li></ol>
C. The disturbance causes clinically significant impairment in social, occupational, or other important areas of functioning.
D. There is no clinically significant general delay in language (e.g., single words used by age 2 years, communicative phrases used by age 3 years).
E. There is no clinically significant delay in cognitive development or in the development of age-appropriate self-help skills, adaptive behaviour (other than in social interaction), and curiosity about the environment in childhood.
F. Criteria are not met for another specific Pervasive Developmental Disorder or Schizophrenia.

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Table A3

*Diagnostic Criteria for 299.80 Pervasive Developmental Disorder - Not Otherwise Specified*

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299.80 Pervasive Developmental Disorder - Not Otherwise Specified
This category should be used when there is a severe and pervasive impairment in the development of reciprocal social interaction associated with impairment in either verbal or nonverbal communication skills or with the presence of stereotyped behaviour, interest, and activities, but the criteria are not met for a specific Pervasive Developmental Disorder, Schizophrenia, Schizotypal Personality Disorder, or Avoidant Personality Disorder. For example, this category includes 'atypical autism' – presentations that do not meet the criteria for Autistic Disorder because of late age at onset, atypical symptomatology, or subthreshold symptomatology, or all of these.

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From: American Psychiatric Association. (2000). Pervasive developmental disorders. In *Diagnostic and statistical manual of mental disorders- text revision* (DSM-IV-TR; 4<sup>th</sup> ed., pp 69-70). Washington, DC: Author.

## Appendix B

### Intraclass Correlation Coefficients

Table B1

*Intraclass Correlation Coefficients for the attention variables recorded in the semi-naturalistic setting.*

Attention Variables	Intraclass Correlation Coefficient
Mean attention shifts p/min	.94***
Percentage of time fixated on objects	.92***
Percentage of time fixated on faces	.89***
Percentage of time fixated on bodies	.75**
Percentage of time unfocused	.92***
Mean shifts face ↔ face p/min	.93***
Mean shifts object ↔ object p/min	.98***
Mean shifts face ↔ object p/min	.95***
Mean shifts face ↔ body p/min	.69**
Mean shifts object ↔ body p/min	.86***
Mean duration of fixations to objects	.94***
Mean duration of fixations to faces	.75**
Mean duration of fixations to bodies	.92***
Mean duration of time unfocused	.90***

\*\*  $P < .01$ , \*\*\*  $P < .001$

Table B2

*Intraclass Correlation Coefficients for the positive social behavior variables recorded in the naturalistic setting.*

Positive Social Behaviour	Intraclass Correlation Coefficient
Total positive social behavior score	.89***
Social Smile	.96***
Initiates affection	.80**
Reciprocates affection	.65*
Initiates sharing	.91***
Reciprocates sharing	.70**
Initiates help (self)	NA
Responds to offer of help (self)	NA
Initiates help (other)	.78**
Responds to request for help (other)	NA
Initiates play	.87***
Responds to play offer	.66**
Initiates sharing experience	.87***
Responds to shared experience of another	.77**
Initiates expression of interest	.92***
Responds to expression of interest	.90***
Initiates greeting	.95***
Responds to greeting	.67**

\*  $P < .05$ , \*\*  $P < .01$ , \*\*\*  $P < .001$

Table B3

*Intraclass Correlation Coefficients for the play variables recorded in the naturalistic setting.*

Play Variables	Intraclass Correlation Coefficient
Unoccupied play	.70**
Solitary play	.93***
Onlooker play	.83**
Parallel play	.94***
Associative play	.84**
Cooperative play	.96***

\*  $P < .05$ , \*\*  $P < .01$ , \*\*\*  $P < .001$



## Appendix C

### Definitions of Positive Social Behaviours

#### *General Definitions*

**Positive social behaviour:** Social behaviour (verbal or non-verbal) that leads to an appropriate social interaction with peers. These are typically behaviours that serve to start or maintain a social interaction.

**Social initiations:** Behaviours used by the child to begin a new social interaction. A new interaction is differentiated by the previous interaction by a change in the peer(s), activity, or the previous interaction sequence by 5 seconds (Huack et al., 1995).

**Social responses:** The child's response (verbal or non-verbal) to social behaviour directed towards him / her by his / her peers (Bauminger, 2002; Huack et al., 1995).

#### *Specific Positive Social Behaviours*

**Social Smile:** Social smile either initiated by the child or in response to a smile from a peer. The child should show some level of social connectedness or engagement (e.g., smiling in response to something a peer did / said; or in response to something the child did / said to or with a peer). The social smile may be recorded with or without eye contact.

**Affection – Initiates:** The child expresses affection toward another child, either verbally (e.g., “I like you”, “You are my best friend”) or non-verbally (e.g., puts arm around or hugs peer; holds peers hand).

**Affection – Response:** The child responds appropriately to affection directed toward him / her by a peer, either verbally (e.g., “I like you too”) or non-verbally (e.g., puts arm around peer; or simply allows peer to put arm around him / her).

**Sharing object – Initiates:** Offers object to a peer either verbally (e.g., “Do you want a \_\_\_\_?”) or non-verbally.

**Sharing object - Response:** Takes an object offered by a peer, or politely declines.

**Help (self) - Initiates:** The child asks a question for information or requests help for self. Request for help may be verbal (e.g., “Can you please help me?”, “Can you open this?”) or non-verbal (e.g., offering a container to a peer to open for him / her).

**Help (self) – Response:** The child responds appropriately to an offer of help from a peer. The child can accept or politely decline the help. Responses can be verbal or non-verbal.

**Help (other) - Initiates:** The child offers to help a peer either verbally (e.g., “Do you want some help?”, “Do you want me to dress the doll for you?”) or non-verbally (e.g., picking up an object the peer dropped and handing it back to the peer).

**Help (other) - Response:** The child responds appropriately to another child's request for help either verbally (e.g., giving instructions re: how to do something; answering a question for information) or

non-verbally (e.g., the child takes an object a peer is having trouble opening and opens it for him / her).

**Play bid - Initiates:** The child approaches a peer with a social (not functional) intention either verbally (e.g., “Can I play with you?”, “Do you want to play \_\_\_?”) or non-verbally (e.g., joins in game, throws ball to peer etc).

**Play bid - Response:** The child responds appropriately to a play bid from a peer. Responses can be verbal (e.g., “yes, I want to play”) or non-verbal (e.g., joining in the game).

**Sharing experiences (about self) - Initiates:** The child shares something about what he / she did / something he / she has etc. Sharing can be verbal (e.g., telling a peer about a toy he / she has / something he / she did on the weekend) or non-verbal (e.g., showing (not giving) a peer a toy he / she has / a picture he / she made). The child may share about something present (e.g., something he / she has) / not present (e.g., something he / she did on the weekend).

**Sharing experiences (about self) – Response:** The child responds to a question about what he / she has or did; or reciprocates a statement made by a peer with something about him/herself (e.g., peer says “I went to the soccer on the weekend”; the child says “I also went to the soccer”). The child can reciprocate with something present / not present.

**Expresses interest (other) – Initiates:** The child asks a peer a question about something he / she did / has / likes / feels (e.g., “What’s your favourite game?”; “What are you playing with?”).

**Expresses interest (other) – Response:** The child comments or asks a question about something a peers says / has. The comment needs to be related to the peer, and in response to something the peers shows / tells him / her (e.g., (1) the peer shows the child his / her new toy. The child asks when he / she got it; what you can do with it etc. (2) the peer tells the child that he she feels sad. The child asks why.

**Greeting - Initiates:** Greets another child either verbally (e.g., “hello”) or non-verbally (e.g., “waves”).

**Greeting - Response:** Responds appropriately to a greeting from a peer.

## Appendix D

### Definitions of Social Play

Code letters, definitions and scoring for the Parten play categories (Ballard, 1981, p188).

*U = UNOCCUPIED BEHAVIOUR = Score 0*

This child apparently is not playing, but is occupied with watching anything that happens to be of momentary interest. When there is nothing exciting taking place, s/he plays with her/his own body, gets on and off chairs, just stands around, follows the teacher, or sits in one spot glancing around the room. The child does not have play equipment.

*S = SOLITARY INDEPENDENT PLAY = Score 1*

The child plays alone and independently with toys that are different from those used by the children within speaking distance and makes no effort to get close to other children. S/he pursues her/his own activity without reference to what others are doing. The child has play equipment.

*O = ONLOOKER = Score 2*

The child spends most of her/his time watching the other children play. S/he often talks to the children whom s/he is observing, asks questions, or gives suggestions, but does not overtly enter into the play her/himself. This type differs from the unoccupied in that the onlooker is definitely observing particular groups of children rather than anything that happens to be exciting. The child stands or sits within speaking distance of the group so that s/he can see and hear everything that takes place. The child does not have play equipment.

*P = PARALLEL ACTIVITY = Score 3*

The child plays independently, but the activity s/he chooses naturally brings her/him among other children. S/he plays with toys that are like those which the children around her/him are using but s/he

plays with the toy as s/he sees fit and does not try to influence or modify the activity of the children near her/him. S/he plays beside rather than with the other children. There is no attempt to control the coming or going of children in the group.

*A = ASSOCIATIVE PLAY = Score 4*

The child plays with other children. The conversation concerns the common activity; there is borrowing and loaning of play material; following one another with trains or wagons; mild attempts to control which children may or may not play in the group. All the members engage in similar if not identical activity; there is no divisions of labour, and no organisation of the activity of several individuals around any material goal or product. The children do not subordinate their individual interests to that of the group; instead each child acts as s/he wishes. By her/his conversation with the other children one can tell that her/his interest is primarily in her/his associations, not in her/his activity. Occasionally, two or three children are engaged in no activity of any duration, but are merely doing whatever happens to draw the attention of any of them.

*C = COOPERATIVE OR ORGANISED SUPPLEMENTARY PLAY = Score 5*

The child plays in a group that is organised for the purpose of making some material product, or of striving to attain some competitive goal, or of dramatising situations of adult and group life, or of playing formal games. There is a marked sense of belonging or of not belonging to the group. The control of the group situation is in the hands of one or two of the members who direct the activity of the others. The goal as well as the method of attaining it necessitates a division of labour, taking of different roles by the various group members and the organisation of activity so that the efforts of one child are supplemented by those of another.

From Ballard, K.D. (1981). An observation procedure for assessing children's social behaviours in free play settings. *Educational Psychology*, 1(2), 185-199.

## Appendix E

### First-Order False Belief Task: The Chris and Eddie Task

Two puppets, two different coloured opaque boxes (one white and one blue) and a matchbox car were required. To begin, the two opaque containers were placed on the table, and Chris and Eddie were introduced as friends who like to play together. The experimenter further stated that their favourite game was to play “cars”. They played with the cars briefly until the experimenter said that Chris was hungry and wanted to go to and get some lunch. Before going to lunch, however, Chris put his car away in one of the containers (either blue or white, counterbalanced within group). Following this, the children were told that Eddie wanted to play with the car for a bit longer, so he took the car from the container and played with it briefly before also leaving to eat his lunch. Before he left, however, he placed the car away under the second container and left.

When Chris returned, the experimenter stated that he wanted to play with the car. At this point children were asked the false belief question “*Where will Chris think the car is?*” followed by the reality question “*Where is it really?*” Children were credited with an understanding of false belief on this task if they (1) indicated the empty container when asked about the puppet’s belief and (2) accurately recalled the car’s true location. Only one trial of this task was conducted.

## Appendix F

### First-Order False Belief Task: The Smarties Task

A large empty smarties box containing approximately six coloured pencils were required for this task. The participant was then asked about the next person to enter the room (either a sibling, parent or staff member at CARD). It was important to establish this before the administration of this task. *"Who will come in after you?"* The child responded with *"(name)"*. The experimenter continued *"S/he hasn't seen this box. When s/he comes in, I'll show her/him this box just like this and ask what's in here?"* Prediction test: *"What will (name say)?"* (correct answer = smarties). Reality check: *"Is that what is really in the box?"* (correct response = no). *"What is really in the box?"* (correct answer = pencils). Memory check: *"Do you remember, when I took the box out of my bag and asked you when was in it, what did you say?"* (correct answer = smarties). In order to pass this test, subjects were required to answer all prompt and check questions correctly as well as the prediction question. Only one trial of this task was administered.

## Appendix G

### Emotion False Belief Task

The emotion false-belief task (Harris, Johnson, Hutton, Andrews, & Cooke, 1989) consisted of a story in which participants are introduced to two toy monkeys, Mickey and Pingu. A story is told in which Pingu likes a particular drink (i.e., Coke) and hates another (i.e., milk). Pingu exits, Mickey replaces the Coke with milk, Mickey exits, and then Pingu returns home thirsty. Children are asked how Pingu feels before he looks in his can (emotion question), what Pingu thinks is in the can (false belief), and other control questions. For example, a participant would pass the task if they said Pingu would feel happy/excited before he looks into the can (emotion) because he thinks it is filled with Coke (false belief), in addition to control questions. The script of Harris et al. (1989) was used. Only one trial of this task was conducted.

**Question 1:** How does Pingu feel when his Mom gives him a can of coke? Does he feel happy or sad?  
... Yes, and why does he feel happy / sad?

**Memory check:** What is in this can?

**Question 2:** How did Pingu feel when he first looked at the can on the table, before he had a look inside it? Did he feel happy or sad? ... Yes, and why was Pingu happy / sad?

**Question 3:** How will Pingu feel when he has a look inside the can and finds that there's milk inside instead of coke? Will he feel happy or sad? ... Yes, and why will Pingu feel happy / sad?