

LOOK AT ME:  
THE IMPORTANCE OF DYADIC SOCIAL  
ENGAGEMENT AMONG PRESCHOOL CHILDREN  
WITH AUTISM SPECTRUM DISORDERS

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Both papers included in this thesis are manuscripts in prep. I took the lead role in the research, design, implementation, analyses, interpretation and writing of both manuscripts. My supervisor, Dr. Kim Cornish, gave substantial inputs into the research design and provided editorial comments to the manuscript drafts.

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## ABSTRACT

There is substantial evidence that young children with an Autism Spectrum Disorder (ASD) demonstrate delays in joint attention development. However, research also documents that abnormalities in earlier-occurring dyadic behaviours contribute to children's delay in establishing triadic joint attention. Although children with autism demonstrate atypical eye contact during dyadic interactions, little is known about the development of this skill among young children with autism. Across two studies, the current project examined gaze perception in young children with an ASD in relation to their developing social and communication skills. The first manuscript used a novel, computerized task to compare the gaze detection skills of children with an ASD to typically developing (TD) children matched on either chronological or mental age. Although children's performance was not influenced by the manipulation of gaze direction, the results are supportive of atypical patterns of attention to faces in autism. Performance data showed that children with an ASD demonstrated fewer orienting responses and shorter fixation times to faces in comparison to TD children. Performance was also positively correlated with level of communicative ability among children with an ASD, but not to measures of developmental or social functioning. The second manuscript piloted the computerized task as an outcome measure of treatment effectiveness using a randomized control design to examine whether children's gaze detection skills are malleable in early childhood following a parent-mediated social communication intervention. Similar to the first manuscript, children's performance was not influenced by gaze direction

revealing that the computerized task requires further development as a measure of face processing for young children. Although findings fell short of significance, a trend emerged in the performance of children whose parents participated in the training program. Specifically, children in the treatment group demonstrated emerging developmental gains in their ability to orient and fixate on faces, as well as their ability to respond to or initiate joint attention. The results inform early detection and intervention practices regarding the importance of developmental-based approaches to understand the manifestation of autism. Additional theoretical and applied implications as well as avenues for future research are discussed.

## RÉSUMÉ

Nous avons des preuves solides que les jeunes enfants atteints d'un Trouble du Spectre de l'Autisme (TSA) font preuve d'un retard dans le développement de l'attention mutuelle. Toutefois, les recherches fournissent aussi des informations sur le fait que les anomalies des premiers comportements dyadiques contribuent aux retards des enfants dans l'établissement de l'attention mutuelle triadique. Bien que les enfants autistiques manifestent un contact visuel atypique lors des interactions dyadiques, on en sait peu sur cette capacité chez les enfants atteints d'autisme. A travers deux études ce projet étudie la perception visuelle chez les jeunes enfants atteints d'un TSA en relation avec le développement de leurs capacités sociales et communicationnelles. Le premier manuscrit utilise une tâche informatisée originale qui compare les compétences de détection du regard des enfants atteints d'un TSA à celles des enfants se développant typiquement (DT) selon soit leur âge mental soit leur âge chronologique. Bien que les performances des enfants ne soient pas influencées par la manipulation de la direction du regard, les résultats sont en faveur des modes atypiques de l'attention aux visages dans l'autisme. Les données de performances montrent que les enfants atteints d'un TSA font preuve de moins de réponses d'orientation, et de temps de fixation plus courts des visages, comparés aux enfants (DT). Les performances sont donc absolument corrélées au niveau de la capacité à communiquer chez les enfants atteints d'un TSA, mais non pas aux mesures du fonctionnement social ou du développement. Le second manuscrit pilote la tâche informatisée comme une mesure des résultats de l'effectivité du

traitement utilisant une conception de contrôle aléatoire pour examiner si les capacités de détection du regard des enfants sont malléables dans la petite enfance à la suite de l'intervention d'une communication sociale par l'intermédiaire des parents. De manière analogue au premier manuscrit, les performances des enfants ne sont pas influencées par la direction du regard et elles révèlent que la fonction informatisée nécessite des développements supplémentaires afin de pouvoir mesurer le traitement des visages chez les jeunes enfants. Bien que les enquêtes ne soient pas suffisamment significatives, une tendance se dessine dans les performances des enfants dont les parents participent à un programme de formation. En particulier, les enfants faisant partie du groupe de traitement manifestent des progrès dans leurs capacités à orienter et à fixer les visages, aussi bien que dans leurs capacités à répondre ou à initier une attention mutuelle. Les résultats renseignent les pratiques de détection et d'intervention précoces en ce qui concerne l'importance des approches fondées sur le développement pour comprendre comment l'autisme se manifeste. Des implications théoriques et appliquées supplémentaires aussi bien que des voies possibles pour de futures recherches sont ici discutées.

## GENERAL INTRODUCTION

Developmental trajectories beginning from early childhood provide a window for identifying underlying processes that drive development towards specific outcomes. For instance, children diagnosed with an Autism Spectrum Disorder (ASD; also referred to as autism in reference to the autism spectrum) demonstrate pervasive impairments in social reciprocity and communication. Early markers of this impairment are noticeable deficits in joint attention, which refers to episodes of shared awareness between a child, their social partner, and an object or event in their environment. Subsequently, it has been hypothesized that deficits in joint attention deprive young children with autism of information critical to social cognitive development (Mundy & Burnette, 2005). In typical development however, earlier developing dyadic interactions between children and their caregivers facilitate episodes of triadic joint engagement. Although dyadic interactive experiences are relatively ignored in the autism related literature (Leekam & Ramsden, 2006), difficulties in interpersonal engagement are at the heart of impairments among children with an ASD, who are less likely to look at faces and use eye contact. Specific developmental precursors to joint attention may then contribute to the profound impairment in social cognition that is characteristic of autism.

Juxtaposing children with an ASD and with typical development presents an opportune context for contrasting the role of early developmental precursors for later social cognitive competence. For instance, faces are crucially important in development because they are a complex, dynamic and fundamental source of

social information (Berger, 2006). In fact, our social behaviour is in part driven by the information we monitor from the visual cues displayed by the faces of our social partners. Attending to these characteristics subsequently supports the emergence of dyadic and triadic interactive experiences that are critical for later social communication competence (Skuse, 2003). As a result, an early emerging preference for faces in typical development provides the social building blocks for higher order social communication skills, which include joint attention, language, and theory of mind.

Given the precedence in development, there is a clear basis for focusing on early social milestones to help appreciate the origin and maintenance of deficits associated with ASD. In particular, if an abnormal degree of attention is attributed to faces early in development, then it is likely to place an obstacle in the developmental path of typical social communication. In the following section, the preverbal and language-related social cognitive processes characteristic of typical development will be outlined as a framework for understanding the atypical developmental trajectory of early social communication skills among young children diagnosed with an ASD.

#### Typical Developmental Trajectory of Nonverbal Social Communication

##### *Newborn Face Preferences*

Critical to typical social development is an intrinsic preference to orient to social stimuli, especially human faces (Valenza, Simion, Cassia, & Umiltà, 1996). Research on neonatal visual perception indicates that newborns prefer to look at face relevant patterns versus non-facelike displays in clinical investigations

(Johnson, Dziurawiec, Ellis, & Morton, 1991; Umiltà, Simion, & Valenza, 1996; Valenza et al., 1996) and even to faces within their natural environments (Farroni et al., 2005). Currently, research is largely concerned with understanding the underlying mechanisms that contribute to newborns' preference for visual patterns. Two competing explanations currently dominate the field of cognitive science. Briefly, the *structural hypothesis* attributes newborns' face preference to an innate matching template of the structural properties of human faces, which biases the visual orientation of neonates towards face-like schematic patterns (Turati, Simion, Milani, & Umiltà, 2002). Alternatively, the *sensory hypothesis* predicts that the psychophysical properties of stimuli control newborns' visual preferences. Although this latter interpretation successfully accounts for infants' preferences for a variety of visual patterns, it fails to explain empirical observations concerning newborns' face preference (Turati et al., 2002). As a result, experimental researchers are presently focused on elucidating the nature of infants' visual face-like preference with respect to the structural properties of human faces.

Research related to the structural hypothesis reveals that newborns' preference for face-like patterns is more aptly qualified by general nonspecific properties of stimuli rather than to specific elements of facial configurations. For example, Turati et al. (2002) conducted several investigations to address whether newborns' face preference was determined by the unique structure of a face (i.e., three high-contrast blobs in a triangular formation corresponding to the eyes and mouth regions in a face-sized image) or by general structural properties of stimuli

not related to facedness. In a series of preferential looking paradigms, they found that newborns' face preference was elicited by the presence of up-down asymmetry (i.e., a greater number of elements in the upper portion of the configuration) among a variety of face-like and non-face-like stimuli. Thus, a critical component of newborns' face preference is the presence of a higher number of elements in the upper portion of a visual arrangement.

Turati, Valenza, Leo, & Simion (2005) presented an interesting developmental finding regarding up-down asymmetry and facedness using natural face images with infants 3-months of age. Although up-down asymmetry among non-face patterns elicited a visual preference among newborns, Turati et al. (2005) demonstrated that up-down asymmetry alone was not sufficient for eliciting 3-month-olds' visual preference for faces. Using natural face images, they demonstrated that unlike newborns, 3-month-old infants rely on the presence of perceptual cues that are specific to faces. Specifically, their evidence revealed that the upper portion of a face, which corresponds to the location of the eyes, is a major factor in attracting infants' visual orientation. As a result, infants' face preference reflects early constraints of the visual system, which biases newborns' visual orientation toward the eye region of faces.

Current research places a particular importance on the processing of information from the eyes, which are considered the most important facial feature (Farroni et al., 2005; Farroni, Csibra, Simion, & Johnson, 2002). Eyes are salient components of the face that provide information about the emotional and mental states of others (Emery, 2000). Although social psychologists have long asserted



the functional significance of eye gaze for regulating behaviour in social encounters, the perceptual and cognitive processes underlying gaze and gaze direction have only recently emerged in the scientific literature (Langton, Watt, & Bruce, 2000). An in depth analysis of gaze processing is particularly important as researchers have proposed a developmental link between early gaze detection skills and the underpinnings of joint attention (Reid, Striano, Kaufman, & Johnson, 2004). For the purposes of the present discussion, gaze processing will be reviewed as it relates to the perception of faces and to the implications for later social communication abilities.

### *The Role of Direct Gaze*

Eye contact, or mutual gaze, provides the central medium through which humans establish a communicative context (Farroni et al., 2002). Research on neonatal visual perception has identified that even newborns demonstrate a unique sensitivity to direct gaze, which serves as an essential foundation for the development of social skills (Farroni et al., 2002). For example, neonates a few hours old spend significantly more time viewing faces with eyes open rather than eyes closed (Batki, Baron-Cohen, Wheelwright, Connellan, & Ahluwalia, 2000). Similarly, newborns no more than 5-days-old demonstrate a special sensitivity to faces with a direct gaze as opposed to faces with the gaze averted (Farroni et al., 2002). More recently, Farroni, Massaccesi, Menon & Johnson (2007) demonstrated that direct gaze also elicits a deeper processing of a person's face, such as their identity. From early on then, direct gaze facilitates the processing of facial and social information.

Even in adulthood, human beings remain uniquely sensitive to direct gaze. Using a visual search paradigm with realistic stimuli, Conty, Tijus, Hugueville, Coehlo, and George (2006) demonstrated that direct gaze was detected faster and more accurately than averted gaze among adult participants. However, this effect was only significant when the head orientation was averted rather than when gaze was presented from a frontal head view. Since gaze contact acts a cue to reciprocal social attention, the authors argued that the intentional nature of direct gaze facilitated its faster detection, which became particularly salient when the head and gaze orientations were incongruent. As a result, direct gaze is functionally significant within social contexts by conveying intent to an observer.

### *Gaze Monitoring*

From birth, typically developing infants show a preference for static faces that engage them in a direct gaze as opposed to faces with their gaze averted. The significance of averted gaze subsequently emerges among older infants to elicit shifts of attention and to support the development of joint attention (Grice et al., 2005). Averted gaze processing refers to individuals orienting themselves to external events or objects for the purpose of following the intentional gaze of their social partner (Skuse, 2003). Subsequently, the emergence of gaze monitoring is fundamental to referential communication (Hood, Willen, & Driver, 1998). Until recently, the majority of studies regarding averted gaze indicated that gaze monitoring emerged during the second year of postnatal life and became more accurate with experience.

In a groundbreaking study, Hood et al. (1998) performed two

investigations to determine whether infants were capable of shifting their visual attention in a direction consistent with which an adult's eyes turned. They addressed this question among young infants despite prevailing evidence indicating that infants do not reliably orient in the direction of adults' attention until at least 2-years of age. Using a spatial cueing attention paradigm, Hood et al. (1998) measured the latency and accuracy of saccades to a peripheral target in which the location of the target stimulus was either congruent or incongruent with the gaze direction of the centrally depicted face. During this task, when attention is directed to a particular location, the visual processing of targets in that location is facilitated. In contrast, when the target appears in the incongruent location reaction times are observably slower. Hood et al.'s (1998) results indicated that preverbal infants as young as 3-months of age detected shifts of attention in adults' eyes and that this detection produced a corresponding shift of the infant's visual orientation and attention. That is, the authors argued that infants are able to use adults' gaze deviation as an attentional cue. Consequently, these results suggest that early gaze processing skills that are necessary for the development of joint attention begin to emerge very early in life.

In response to this study, Farroni, Johnson, Brockbank, and Simion (2000) challenged Hood et al.'s (1998) findings by suggesting that their results were potentially confounded by perceived motion during the gaze cueing paradigm. In particular, Farroni et al. (2000) contended that the infants were not using eye gaze as an attentional cue but rather that the critical mechanism responsible for an infant's shift of attention was their early sensitivity to motion, which was apparent

in the direction of movement of the pupils. Accordingly, their results confirmed that the most salient cue in the computerized paradigm employed by Hood et al. (1998) was the apparent motion of the pupils rather than the final end state of the eye gaze direction. Consequently, infants are not capable of processing the final state of an averted gaze as a *functional* cue to direct their visual orientation and attention. Rather, directed movement contributes to the behavioural cueing effects of averted gaze among infants under 6-months of age (Farroni et al., 2000).

Interestingly, Farroni, Mansfield, Lai, and Johnson (2003) provided a systematic investigation of cueing effects among 4-month-old newborns to address the nature of infant eye gaze perception. From their experiments, Farroni et al. (2003) uniquely identified that target-driven cueing effects in a visual cueing paradigm were only observed when a brief period of mutual gaze was administered first within the context of an upright face. In combination with earlier findings from Farroni and colleagues (2000), these researchers suggested that mutual gaze initially engages the attentional mechanisms that facilitate cueing responses associated with gaze shifts, which occur because of perceived motion of the pupils (or any subsequent movement). Thus, this study underscores the special significance of mutual gaze in typical development for the emergence of early gaze processing skills, such as gaze shift perception.

Among older infants, Brooks and Meltzoff (2002) assessed whether gaze following is due to an infant's understanding of referential acts or elicited by the visual movement of an adult's head turn. In separate experiments, Brooks and Meltzoff compared infants' responses to an adult's head movement when the eyes

were open or closed and when the experimenter wore a form of visual occluder (i.e., a headband that covered the examiner's forehead or a blindfold obstructing the examiner's view). Among 12-, 14-, and 18-month-olds, they found that infants attended to and inspected the targeted objects longer when the adult experimenter had an unobstructed view of the object (i.e., eyes open or a headband).

Furthermore, within these conditions, 14- and 18-month-olds pointed more frequently at the visually directed object. Rather than relying on head cues, infants process the eye status of their interactive partners as object-directed, bringing meaning to referential acts that are toward an external object. Developmentally then, 12- to 18-months of age represents a window where gaze following becomes fundamental to higher order mentalistic attributions, such as attention sharing (Brooks & Meltzoff, 2002).

#### *The Relationship between Gaze Processing and Joint Attention Development*

Early joint attention skills take a variety of forms and emerge gradually throughout early development to acquire a shared awareness for the mental states of others. These skills include attention following, social referencing, imitation, and showing or sharing objects of interest. Previously, theorists posited that joint attention skills abruptly emerge at the end of first year as children begin to understand others as intentional agents (Carpenter, Nagell, & Tomasello, 1998). However, authors of recent studies suggest that infants begin to demonstrate various joint attention skills much earlier in life. Whether these skills signify that an infant is capable of representing another's state of mind remains a topic of considerable debate.

Children may progress from dyadic interactive contexts (e.g., face-to-face exchanges for neonatal imitation and vocalizations) to triadic social engagement (e.g., joint attention) on the basis of developing social cognitive skills. In support of this idea, Striano and Rochat (1999) established a developmental link between dyadic and triadic social competence in infancy. In particular, infants who demonstrated high scores during the dyadic phase of their investigation were also those who scored highly during the triadic episodes. The authors concluded that the emergence of general social competencies in dyadic, face-to-face interactions contributes to the appearance of other dyadic and triadic skills. According to the authors, such competencies include social initiatives in dyadic contexts, which were characterized by an infant's ability to engage in face-to-face contact, or rather, to establish eye contact with their social partner. Thus, this research supports the idea that mutual gaze, or at least face-to-face interaction, is a necessary precursor for other dyadic and later triadic social cognitive skills.

Striano and Bertin (2005) investigated the developmental trajectory of triadic joint attention skills among infants aged 5- to 10-months and included tasks of joint attention skills from earlier in life than previously investigated. In doing so, they assessed coordinated attention (i.e., do infants alternate their gaze between an object and the experimenter?), gaze following (i.e., do infants follow the attention directing cues of the experimenter to an object?), point following (i.e., do infants follow the pointing finger of an experimenter to target toys?), blocking (i.e., how do infants react to social obstacles?), and teasing. During their investigation, Striano and Bertin observed that infants succeeded on most of the

triadic social tasks before 9-months of age and that performance did not increase significantly between 5- and 10-months. In a more fine tuned investigation, Striano and Stahl (2005) demonstrated that even infants as young as 3-months of age were able to follow gaze direction if an adult's attention was initially directed at an object. Taken together, these results indicate that an infant's ability to follow gaze direction is a necessary precursor for more robust triadic competencies, which provide the developmental origins of perceiving and understanding others as intentional agents.

By 5-months of age, infants demonstrate an emerging understanding for the function of eye contact in interactive communication (Delgado, Messinger, & Yale, 2002). In fact, developmental differences are apparent in early joint attention skills among children classified at various stages of eye processing capabilities. In line with this idea, Moore, Angelopoulos, and Bennet (1997) found that 9-month-old infants who were able to monitor changes in eye gaze at the outset of their study were also those who recognized the value of a head tilt as representing an intentional movement on an adult's behalf. Moreover, 9-month-old infants who did not engage in gaze following at the outset of the study were able to learn the significance of a head tilt in the experimental context. However, this finding was only observed when infants were presented with a dynamic head turn, rather than a final static head orientation. As a result, infants may acquire an appreciation for the visual regard of their social partners as they continue to experience joint attention situations that encourage such skills early in life.

An infant's ability to actively participate in triadic exchanges provides

essential social knowledge, which allows infants to first acquire language and eventually develop a more sophisticated mentalistic understanding (Carpendale & Lewis, 2004). Morales, Mundy, and Rojas (1998) found that individual differences in an ability to match gaze direction at 6-months of age were related to language development in the second year of life. Given the developmental link between joint attention and language, these authors concluded that the capacity to match gaze at 6-months represents a valid marker of joint attention skill development early in ontogeny. Brooks and Meltzoff (2005) suggest that there is a developmental transition at 9-months of age in infants' understanding of adult looking. Whereas 9-month-old infants orient to head motion in gaze following paradigms, the referential nature of gaze is salient to older infants at 10- or 11-months of age. Rather than relying on head movement cues, older infants become sensitive to the perceptual status of the eyes and begin to understand the possibility of psychological sharing. Throughout infancy then, while children develop gaze monitoring skills, they also coordinate their attention with others and begin to learn language (Carpendale & Lewis, 2004).

Lee, Eskritt, Symons, and Muir (1998) distinguished between dyadic and triadic eye gaze. They outlined that dyadic eye gaze is used to regulate face-to-face interaction, whereas triadic eye gaze, is used to reveal the focus of attention or internal states of social partners. The authors do note however that triadic eye gaze also functions to monitor one-on-one interactions. This contextual distinction is especially relevant when considering children's sensitivity to eye gaze and their use of gaze information across different situations, such as face-to-face



interaction, joint attention activity, and referential communication. Thus, among 2- to 5-year-olds, Lee and colleagues (1998) examined the developmental function of triadic eye gaze with respect to higher level social processing skills, namely to infer the intentions of others. In their investigation, 2-year-olds were able to infer another's mental state using eye gaze information that was dynamically displayed without any additional nonverbal attentional cues, such as pointing or head direction. However, if children were presented with static pictorial images of eye gaze information, only 4-year-olds were able to infer another individual's desires. Throughout development then, as children become more adept social partners, they learn to use eye gaze information more effectively to represent others' beliefs.

In summary, the prevailing opinion among current researchers is that the underlying mechanisms that account for newborn face preferences are also responsible for ensuring that infants fixate on faces in their natural environment (Johnson, 2005). Due to constraints of the visual system within the first months of life, infants preferentially orient toward faces, particularly those engaged in direct gaze. This early sensitivity for mutual gaze is necessary for the development of human relationships where gaze provides critical information, such as in adult-infant interactions (Farroni et al., 2003). Averted gaze then emerges and is refined through experience to allow us to accurately follow the gaze of another. The implications of eye gaze are represented in referential communicative acts where gaze perception is critical for learning language and developing an understanding of others' mental states. These findings raise the possibility that the absence of

sensitivity to direct gaze may represent an underlying mechanism for understanding abnormal social cognitive development, particularly in the case of autism.

#### Nonverbal Social Communication Development in Autism Spectrum Disorders

In an effort to provide a thorough account of ASD, it may be fruitful to identify developmental processes in typical development that fail to mature in a similar trajectory in autism. For instance, typically developing infants preferentially orient to faces, which is part of a developmental process that leads to the emergence of spontaneous gaze-following behaviour (Nation & Penny, 2008), and establishes interactive contexts critical to joint attention development. During joint attentional episodes, typically developing infants gradually acquire a number of social cognitive skills, which facilitate language learning and provide the developmental origins of perceiving and understanding others as intentional agents. However, children with an ASD display a range of social cognitive impairments within the first year of life, which include deficits in social orienting, joint attention, responses to the emotional displays of others, and face recognition (Dawson et al., 2002). In autism then, it is possible that significant variations in infants' sensitivity to human faces may be a behavioural hallmark of developmental differences in the trajectory of early social communication development. As a result, infants with an ASD may fail to appreciate the social significance of eyes, particularly gaze cues, depriving them of social learning opportunities related to words, faces, and objects (Nation & Penny, 2008).

### *The Epidemiology and Diagnosis of ASD*

First coined by Leo Kanner in 1943 as a syndrome of infantile autism, Autistic Disorder is now the classical form of a set of related, complex neurodevelopmental disorders known as Autism Spectrum Disorders (also known as pervasive developmental disorders, PDD). The autism spectrum is defined and diagnosed on the basis of observable behaviours among a triad of impairments, which include communication, reciprocal social interaction, and restricted repetitive and stereotyped patterns of behaviours and interests (APA, 2000). The current approach to the diagnosis of autism is well represented in the DSM-IV and the ICD-10, which include specific classifications of PDD subtypes: Autistic Disorder, Retts Disorder, Child Disintegrative Disorder, Asperger's Syndrome, and PDD-not otherwise specified. (The ICD-10 also includes Overactive disorder with mental retardation and stereotyped movements, for which the DSM-IV has no corresponding diagnosis). Current epidemiological studies estimate that the disorders collectively affect 60 in 10,000 individuals (Fombonne, 2005). Although currently there appears to be an upward trend in autism, the broadening diagnostic criteria, public awareness, and access to services have affected reported prevalence rates (Fombonne, 2005).

According to Fombonne's (2005) most recent epidemiological review, an ASD is more likely to occur in boys than girls (male:female ratio of 4:1). In reviewing the current literature, Fombonne reported that 30% of children with Autistic Disorder are reported to function in the normal range of intelligence, 30% score in the mild-to-moderate range of mental retardation and 40% score in the

severe-to-profound mental retardation range. Across the spectrum of disorders, the preponderance of boys is less pronounced among children with a diagnosis and mental retardation (male:female ratio 2:1), whereas high-functioning children with an ASD are more likely to be male (6 to 8:1). While autism is a strongly genetic disorder with heritability estimates as high as 90%, the genetic underpinnings of autism remain largely unknown due to the genetic heterogeneity of ASDs, which are caused by the action of at least 15 contributing genetic regions (Gutpa & State, 2007). While advances have been witnessed across many areas of expertise to help understand the aetiology, diagnosis, classification and treatment of autism, the majority of contemporary researchers agree that disordered social communicative development is the hallmark of ASD.

#### *Early Clinical Observations of children with ASD*

While clinical experience suggests that there is a lack of social interest among children diagnosed with autism, there are relatively few empirical investigations regarding the development of gaze processing in this population. In light of diagnostic issues, this is not surprising considering children with autism are rarely identified before 3-years of age (Landa & Garrett-Mayer, 2006). Nevertheless, for both theoretical and practical reasons, there is a critical need to identify the nature of early social difficulties in ASD (Maestro et al., 2002). For instance, Maestro et al. (2002) qualified early attention impairments in autism during the first 6-months of life using retrospective home videos. They indicated that infants who later received a diagnosis of an ASD demonstrated limited eye contact as well as diminished social initiatives and responses toward people. By

1-year of age, children identified with autism are also less likely to look at the faces of their social partners in comparison to typically developing children (Osterling & Dawson, 1994) and to children later diagnosed with mental retardation without autism (Osterling, Dawson, & Munson, 2002). Thus, early signs of autism include a failure to orient to other people.

In studies among older toddlers, Clifford, Young and Williamson (2007) examined home videotapes to identify early social deficits between the first and second birthdays that differentiated children with autism from infants who had a developmental or language delay, or who were typically developing. They found that early symptoms of Autistic Disorder stemmed from basic social dyadic behaviours. Specifically, they concluded that the quality of eye contact and positive affect defined the participant groups. Similarly, Wimpory, Hobson, Williams, and Nash (2000) identified that person-to-person behaviours, which included the frequency and intensity of eye contact, were less likely to occur among toddlers with autism, ranging between 2- to 4-years of age. Finally, in a case study of an infant with autism, Dawson, Osterling, Meltzoff, and Kuhl (2000) found that difficulties in social interaction, which were qualified by poor eye contact, emerged at 6-months of age and were still evident during a follow up assessment at 2-years. Thus, infants later diagnosed with autism fail to orient to faces and exhibit diminished eye contact.

While the research reviewed above provides valuable insight into the early behavioural markers of autism, the retrospective nature of these studies is commonly critiqued (Zwaigenbaum et al., 2007). To avoid biases inherent to

retrospective designs, a number of prospective studies among high-risk infants, that is, siblings of children with an ASD, have recently emerged in the literature. For example, Zwaignebaum and colleagues (2005) presented preliminary data, which indicated atypical neurodevelopment characteristic of ASD as early as 6- to 12-months of age. Siblings of children with autism who were later diagnosed with an ASD were distinguished from other siblings and low-risk controls in several areas pertinent to the present discussion, including poor eye contact, limited social responsiveness and reduced social interest. Subsequent prospective studies have consistently identified developmental differences in basic dyadic reciprocity skills of infants at high-risk for an ASD (for examples, see Bryson et al., 2007; Gamliel, Yirmiya, & Sigman, 2007; Merin, Young, Ozonoff, & Rogers, 2007). Consequently, early-onset social attention abnormalities in ASD may limit the importance of faces in general, and eyes in particular, which are vital to extract meaning during social situations.

*Social Orienting Ability.* The social insignificance of faces in ASD might ultimately be linked to a lack of attention toward social stimuli in general. Swettenham et al. (1998) compared the attentional tendencies of typically developing infants with those diagnosed with either a developmental delay or autism using a series of social and non-social stimuli. Between-group differences showed that autistic infants spent shorter durations of time looking at people and looked for longer durations at objects than infants in either the developmentally delayed or typically developing control groups. In addition, infants in both controls groups were more likely to shift their attention between categories of

stimuli that were social in nature, that is, between an object and a person.

However, the orienting pattern observed among infants with autism revealed a preference for switching attention only between objects. In a similar investigation, Dawson and colleagues (Dawson, Meltzoff, Osterling, Rinaldi, & Brown, 1998; Dawson et al., 2004) observed that preschool aged children with autism were less likely to orient to both social and nonsocial stimuli, but were more severe toward social stimuli. From these findings, it can be inferred that social stimuli carry little social or affective meaning for young infants with autism (Elgar & Campbell, 2001). If from early infancy children are not attuned to social stimuli, particularly faces, then this may also contribute to difficulties with eye contact.

#### *Gaze Processing Skills*

The past decade has witnessed a surge of interest regarding the gaze processing skills of individuals with ASD. To date, many researchers have indicated a range of impairments in gaze processing skills in autism, while others have challenged that individuals with autism do in fact demonstrate relatively spared abilities during specific tasks. Although historically few studies have addressed the function of direct gaze among autistic populations, several studies currently exist suggesting that unlike typically developing individuals, persons affected by an ASD do not demonstrate a preferential sensitivity for mutual gaze (Senju, Yaguchi, Tojo, & Hasegawa, 2003; Senju, Hasegawa, & Tojo, 2005; Wallace, Coleman, Pascalis, & Bailey, 2006). Regarding gaze monitoring, a number of studies reveal that individuals with autism demonstrate intact reflexive attention shifting (Chawarska, Klin, & Volkmar, 2003; Kyliainen & Hietanen,

2004; Leekam, Hunnisett, & Moore, 1998; Rutherford & Krysko, 2008), despite difficulties with spontaneous gaze following. However, more fine tuned analysis of this ability identifies that people with an ASD demonstrate different patterns of attention orienting than typically developing individuals, especially with respect to social stimuli (Goldberg et al., 2008; Ristic et al., 2005; Senju, Tojo, Dairoku, & Hasegawa, 2004; Vlamings, Stauder, van Son, & Mottron, 2005). Collectively, these findings show that individuals with autism can accurately discriminate between gaze directions, although they fail to understand the significance of gaze signals as salient social cues (Ames & Jarrold, 2007; Baron-Cohen, Campbell, Karmiloff-Smith, Grant, & Walker, 1995; Leekam, Baron-Cohen, Perrett, Milders, & Brown, 1997). Therefore, impairments in gaze processing cannot be attributed solely to a failure to detect gaze direction, but rather reflects an abnormality in the developmental trajectory of gaze processing skills.

### *Face Processing Skills*

The general consensus among current researchers is that individuals with autism demonstrate abnormal eye contact and fail to use gaze as a salient social cue in their natural environment. Consequently, these deficits contribute to chronic difficulties individuals with autism exhibit when they process social and emotional information from faces. This is not unexpected given the general lack of attention attributed to faces early in development among children with an ASD, which places an obstacle in the developmental path of typical face processing strategies (Grelotti, Gauthier, & Shultz, 2002). For instance, in comparison to typical populations, individuals with autism display pronounced deficits during



facial recognition tasks (Klin et al., 1999; Rose et al., 2007), as well as marked differences in the manner with which they process faces, which is consistent with a reduced salience of the eyes (Dalton et al., 2005; Joseph & Tanaka, 2003; Klin, Jones, Schultz, Volkmar, & Cohen, 2002a; Spezio, Adolphs, Hurley, & Piven, 2007a). Thus, the early social predispositions of children with an ASD may lead to irregular face processing tendencies, which interferes with the recognition of socially relevant information from faces (Adolphs, Sears, & Piven, 2001).

Interestingly, Sasson (2006) suggests that impaired face processing may explain the developmental origins and progression of social deficits characteristic of autism. At the same time however, he alludes to the notion that a failure to establish eye contact, which is characteristic of ASD, may be at the root of impaired face processing. Similarly, Berger (2006) presents a model of preverbal social development in autism, in which he describes the trajectory of dysfunctional eye processing development. In his model, he contends that there is a lack of sensitivity for mutual gaze and a subsequent failure to progress to later forms of eye monitoring in autism. In essence then, Berger (2006) contends that dysfunctional eye gaze underlies difficulties with establishing shared attention to an object or event, namely joint attention.

#### *Joint Attention Development*

Joint attention deficits are one of the most reliable indicators for a diagnosis of autism, distinguishing children with an ASD from children with other developmental delays and typical development (Ventola et al., 2007). There is extant literature documenting the unique impairment in both initiating and

responding to joint attention from infancy through to adolescence among individuals with an ASD (for examples, see Dawson et al., 2004; Leekam & Ramsden, 2006; Osterling et al., 2002; Toth, Munson, Meltzoff, & Dawson, 2006). Importantly however, the consensus across these studies indicates that rather than impairment in joint attention, individuals with autism demonstrate delays in joint attention development where specific behaviours remit with age, particularly one's ability to respond to the attention bid of another. Although theories of joint attention are prominent in the field to explain the psychopathology of autism, more recent investigations question if difficulties with joint attention in fact reflect problems in dyadic interaction (Chiang, Soong, Lin, & Rogers, 2008), and in particular, early impairments in eye contact (Clifford & Dissanayake, 2008).

#### *The Importance of Joint Attention for Intervention*

Delays that occur in either dyadic or triadic interactive experiences likely impact upon other aspects of social development as well. Indeed, researchers emphasize the developmental primacy of joint attention skills for later social communication competence. For instance, interactions that are maintained through episodes of joint attention support the development of pivotal preverbal communication skills (Pruden, Hirsh-Pasek, & Golinkoff, 2006). Thus, the development of joint attention is consistently identified as a reliable predictor of later language outcome in the autism-related literature (Bono, Daley & Sigman, 2004; Charman et al., 2003; Dawson et al., 2004; Drew et al., 2002; Siller & Sigman, 2002). Similarly, as these types of interactions provide scaffolding for

typically developing children's metacognitive growth (Carpendale & Lewis, 2004), children and adults with an ASD are also impaired in many aspects of their social understanding as measured by theory of mind tasks (Adolph et al., 2001; Calder et al., 2002; Ruffman, Garnham, Rideout, 2001; Skuse, 2003). Theorists therefore recognize joint attention skills as an appropriate target for intervention efforts.

It is important to recognize that social and communication deficits characteristic of ASD are apparent early in life among infants' dyadic reciprocity skills (Bryson et al., 2007). Consequently, infants' failure to engage in early social interactions is hypothesized to interfere with social and prelinguistic information that typically promotes social communicative development (Dawson, 2008). More specifically, infants' dyadic skills fail to mature into more developmentally advanced versions, such as joint attention, which typically supports the emergence of higher-order social cognitive skills, including language and theory of mind (Chawarska et al., 2007). As a result, it is necessary to consider the developmental precursors to joint attention as a medium for intervention, which is particularly relevant now given the younger ages at which children are being diagnosed (Schertz & Odom, 2007).

Although impairments in interpersonal communication are central to the manifestation of ASD, only recently have these deficits become the focus of intervention efforts (Kasari, Freeman, & Paparella, 2006). Social communication skills develop out of a continuous, ongoing process during children's daily interactive experiences (Hwang & Hughes, 2000). As a result, treatment programs

that are embedded in enduring forms of interactions are beneficial for the social and communicative development of children with autism. By facilitating social engagement, children can learn about the reciprocal nature of communication and about their role in a communicative dyad. Furthermore, non-verbal social communicative signals are reinforced during joint attention interactions, which allow children to extract meaning from social stimuli, such as faces. Thus, evidence-based intervention practices that increase children's social engagement with their environment should be implemented for children with an ASD.

Given that impairments in social communicative abilities are typical of autism, it is imperative to critically appraise forms of early intervention that are implemented as autism treatments. Several recent studies have provided evidence for specialized intervention programs for young children with an ASD, which result in significant improvement in children's joint attention development (Aldred, Green, & Adams, 2004; Kasari et al., 2006). Furthermore, recent treatment initiatives targeting increases in joint attention behaviours also produce collateral improvements in other social communicative behaviours (Schertz & Odom, 2007; Whalen, Schreibman, & Ingersoll, 2006). Currently however, it has yet to be determined if improvements in joint attention are related to underlying changes in gaze processing development.

### Thesis Objectives

The objectives of this thesis are two-fold: to address limitations in the autism literature and to extend our current knowledge regarding the influence of gaze processing development on social cognition among toddlers diagnosed with

an ASD. Although previous work has helped clarify the nature of children's gaze processing and joint attention impairments, no study to date has examined the relationships between gaze processing, joint attention, and intervention. The first manuscript in the thesis is a preliminary investigation to determine whether toddlers diagnosed with an ASD demonstrate distinct viewing patterns for faces with specific gaze directions in comparison to typically developing controls. Using a novel, forced choice computerized task, this study examines children's spontaneous viewing patterns in relation to their developmental and social communicative functioning. Not only does this study have implications for our understanding of developmental models of autism, it helps elucidate specific factors underlying the developmental pattern of joint attention among children with autism.

The second part of this thesis explores this question within the context of a social and communication intervention for children diagnosed with an ASD. No study to date has investigated the relationship between gaze processing development and treatment effectiveness. The second manuscript examines in a randomized control design the influence of a parent-mediated intervention on children's viewing patterns for faces with different gaze directions. Research suggests that intervention techniques that teach parents to establish reciprocal interactions with their children lead to longitudinal increases in joint attention behaviours (Siller & Sigman, 2002). Subsequently, this second manuscript examines whether collateral changes emerge in children's viewing patterns for gaze directions that are reinforced during joint attentional exchanges and also

facilitate the development of referential communication. Thus, the ultimate goal of this thesis is to provide an in-depth analysis of the perceptual and social communicative abilities of toddlers diagnosed with an ASD.

MANUSCRIPT 1: ATYPICAL PATTERNS OF VISUAL  
ATTENTION TO FACES IN  
AUTISM SPECTRUM DISORDERS

## ABSTRACT

Typically developing infants' sensitivity to direct gaze is essential for the development of their attention cueing and gaze monitoring skills. Although children with autism demonstrate atypical eye contact in dyadic interactions, the role of mutual gaze in the trajectory of children's gaze processing development is unclear. Using a novel computerized task, this study compared the gaze perception skills of preschool children with autism to chronological and mental-age matched controls in relation to their developmental and social communicative functioning. Children with autism demonstrated atypical patterns of attention to faces irrespective of gaze direction, which was associated with their level of language development. Our findings provide support for social orienting impairments in Autism Spectrum Disorders, which have developmental consequences for social cognition.



## Introduction

Delays in joint attention are one of the earliest behavioural manifestations of an Autism Spectrum Disorder (ASD; also called autism to refer to the spectrum of disorders), reflecting an inability to coordinate attention with a social partner to establish a common reference for communication. There are a number of possible explanations that can be inferred from the literature to account for this deficit.

Authors of a prominent theoretical account claim that early onset difficulties in sharing attention underpin life-long impairments in reciprocal social interaction and communication characteristic of ASD (Mundy & Burnette, 2005). Within the typical development literature, there are several investigations that have helped elucidate the etiological mechanisms initiating typical joint attention development (e.g., Carpenter, Nagell, & Tomasello, 1998; Striano & Rochat, 1999; Striano & Bertin, 2005). These developmental data highlight a trajectory of early-occurring social milestones that are fundamental to the emergence of joint attention.

Arguably more important, is the fact that these factors, which involve the ability to attend and process information from faces, are commensurate with the early onset social difficulties associated with ASD.

### *Early social deficits in ASD*

To understand the nature of social difficulties in autism, it is vital to view its manifestations within a developmental framework. Although an ASD is not typically diagnosed until the preschool years, developmental abnormalities may be apparent during the first postnatal months of life. Previous research using retrospective sources has yielded important insights into behaviours that

differentiate children with autism from children with typical development. In the first of year of life, these studies document that infants later diagnosed with an ASD demonstrate difficulties in orienting to social stimuli, responding to their name, looking at people, and making eye contact (e.g., Dawson, Osterling, Meltzoff, & Kuhl, 2000; Maestro et al., 2002; Osterling & Dawson, 1994). It is not surprising then that on average, parents of children with either Autistic Disorder or Pervasive Developmental Disorder-not otherwise specified first notice developmental abnormalities in their child's social and speech development between 14- and 15-months of age, and in certain cases as young as 11-months (Chawarska et al., 2007). By 12-months of age, contemporary researchers suggest that infants with an ASD can be distinguished from infants with developmental delays without autism due to greater impairments in social orienting, receptive communication, social affective engagement, and reactivity (Watson et al., 2007). Thus, research is focused on documenting primary deficits in ASD that evolve within the earliest months of life, and which may be directly linked to later manifestations of autism.

A number of prospective studies among high-risk infants, that is, baby siblings of children with an ASD, have recently emerged in the literature. Infant sibling research presents a unique opportunity to appreciate the developmental trajectories of young infants with an ASD where an early impairment in one domain may have cascading influences on subsequent development. For example, Bryson et al. (2007) provide elegant descriptions of nine high-risk infants followed prospectively from 6- to 36- months of age. Between 6- and 12-months

of age, all but one child showed notable changes in their reciprocal social communication skills, which included reduced or fleeting eye contact, few social smiles, and limited interest or pleasure in interacting with others. Furthermore, these changes in behaviour were more salient at 18-months, predictive of their social communicative impairments at 24-months, and subsequently fulfilled criteria for a diagnosis of an ASD at 36-months. In combination with the findings described above, these studies suggest that prelinguistic infants with an ASD demonstrate developmental differences in their dyadic reciprocity skills (Bryson et al., 2007).

Among infants with autism, there are marked abnormalities in social and communicative functioning within the first few months of life that may initiate an atypical pattern of development and contribute to later manifestations of autism. Accordingly, several theorists argue that young infants with autism demonstrate a general impairment in their orienting ability, which is especially marked with stimuli that have social relevance (Dawson, Meltzoff, Osterling, Rinaldi, & Brown, 1998; Dawson et al., 2004; Leekam, Lopez, & Moore, 2000). For example, when presented with social and non-social stimuli, individuals affected by an ASD fail to orient preferentially to social stimuli (Dawson et al., 1998, 2004; Leekam & Ramsden, 2006; Sasson, Turner-Brown; Hotzclaw, Lam, & Bodfish, 2008; Swettenham et al., 1998), which is a pattern of attention that typically emerges during early infancy and is critical to other social communicative milestones (Farroni et al., 2005; Valenza, Simion, Cassia, & Umiltà, 1996). However in both autism and typical development, an ability to

orient to social stimuli is associated with attention sharing skills, such as an ability to follow the point or gaze of another (Dawson et al., 1998). It is possible then that the social disinterest characteristic of young infants with an ASD presents unique developmental challenges by compromising their participation in face-to-face social interactions that typically underpin social communication development.

### *The Trajectory of Gaze Processing in Typical Development*

For typically developing infants, social stimuli, particularly faces have special significance for later social communicative development. From birth, typically developing newborns prefer to look at faces in clinical investigations (Johnson, Dziurawiec, Ellis, & Morton, 1991; Umiltà, Simion, & Valenza, 1996; Valenza et al., 1996) and within their natural environment (Farroni et al., 2005). Newborns are also sensitive to the eye region of the face, preferring to view faces with the eyes open rather than with the eyes closed (Batki, Baron-Cohen, Wheelwright, Connellan, & Ahluwalia, 2000), or with the gaze averted (Farroni, Csibra, Simion, & Johnson, 2002). This finding is not unexpected as mutual gaze, or eye contact, is critical to infant-caregiver dyads by regulating interactions, expressing intimacy, and establishing affective bonds (Berger, 2006). Within these interactions, mutual gaze also becomes central to infants' reflexive orienting. Specifically, by 4- to 5-months of age, brief periods of mutual gaze (i.e., eye contact) facilitate infants' reflexive shifts of attention to perceived motion in gaze cues (Farroni, Mansfield, Lai, & Johnson, 2003). Corkum and Moore (1998) point out that during this developmental time period infants reliably

experience pairings between another person's eye or head movement and an object or event external to themselves. Subsequently by 10- to 11-months of age, infants spontaneously follow head turns and gaze shifts providing a range of social learning opportunities, which lead to an appreciation of eye gaze as a salient social cue by 18-months when gaze alone can direct infants' attentional orientation (Corkum & Moore, 1998). Early in life then, specific forms of dyadic social engagement, especially that which is expressed in an infant's ability to attend and respond to eye gaze, is vital to the development of joint attention (Dawson, Webb, & McPartland, 2005).

#### *The Trajectory of Gaze Processing in ASD*

*The development of mutual gaze.* Although deviant patterns of reciprocal gaze are a clinically significant feature of ASD, little is known empirically about the function of mutual (i.e., direct) gaze in this population (Senju, Yaguchi, Tojo, & Hasegawa, 2003). A series of experimental studies by Senju and colleagues have highlighted unique findings with respect to the developmental function of mutual gaze in children diagnosed with an ASD. Initially, Senju et al. (2003) compared the performance of children with high functioning autism (HFA; mean age 12 years) to chronologically matched typically developing controls on a visual oddball paradigm, which required participants to respond to one of two rare stimuli (i.e., either a photographed image depicting a direct or averted gaze within a laterally oriented face) interspersed among a series of frequently seen stimuli. Their results indicated that direct gaze facilitated the response speed of only the typically developing participants, whereas children with HFA failed to

preferentially detect mutual gaze. Furthermore, performance did not differ between participant groups in detecting averted gaze suggesting that mutual gaze is independently affected in ASD.

In a follow up investigation, Senju, Hasegawa, and Tojo (2005) also found that children with autism did not show the facilitated behavioural response associated with direct gaze using a visual search paradigm. This type of task typically requires participants to detect a target stimuli as fast as possible from a set of distracters. Using photographs of laterally oriented faces with different gaze directions, Senju et al. (2005) observed that participants with an ASD were not faster at detecting direct gaze from averted gaze distracters in comparison to typically developing controls. To provide a more detailed analysis of this deficit, the authors distinguished between straight and direct gaze. In comparison to *perceived* direct gaze (i.e., when eye gaze direction is incongruent to face orientation producing directed gaze), frontal view faces with straight gaze differ in basic perceptual features, such as the relative position of the iris, which could influence search efficiency (Senju et al., 2005). For instance, the “stare-in-the-crowd” effect (i.e., asymmetry in search performance) refers to the faster detection of direct, or a central staring gaze, from a set of distracters with different gaze directions (von Grönau & Anston, 1995). In subsequent experiments, Senju and colleagues have demonstrated that children with autism show the stare-in-the-crowd effect when presented with schematic eye stimuli (Senju et al., 2005 Experiment 3) as well as with photographs of eye regions and whole, front-view faces (Senju, Kikuchi, Hasegawa, Tojo, & Osanai, 2008). Although there is some

evidence to suggest that children with autism are not sensitive to straight-ahead gazes (see Wallace, Coleman, Pascalis, & Bailey, 2006), children with autism can detect direct gaze faster within the context of front-view faces.

At the same time, individuals with an ASD demonstrate a specific impairment in the perception of direct gaze within an averted face (Senju et al., 2005). To detect direct gaze within a laterally oriented face, the observer must integrate eye direction with head orientation: one of the earliest abilities relevant to joint attention in typical development (Triesch, Teuscher, Deak, & Carlson, 2006). In autism then, early occurring abnormalities in eye contact have cascading consequences for the function of direct gaze in social cognition. As a result, children with autism may not acquire an understanding of the communicative and emotional significance of processing direct gaze, which may contribute to the widely reported difficulties in spontaneous gaze monitoring.

*Gaze detection skills.* A person's ability to orient their attention to an event or object external to themselves is dependent upon an ability to detect the direction of another person's gaze. Research indicates dissociation in autism between detecting gaze direction and the ability to gather information about a person's mental state from their eyes, which suggests that individuals with autism fail to understand the use of eye gaze as a communicative signal (Baron-Cohen, Campbell, Karmiloff-Smith, Grant & Walker, 1995). Two related studies indicate that school-age children with an ASD and a verbal mental age above 4 years display a specific deficit on tasks of volitional and cognitive mental state (e.g, interpreting eye direction to communicate interest in something), despite an intact

ability to succeed on visual perspective taking tasks (i.e., deciphering where someone is looking; Baron-Cohen et al., 1995; Leekam, Baron-Cohen, Perrett, Milders, & Brown, 1997). Given these findings, it is not unexpected that recent data highlight that young children with an ASD demonstrate a developmental delay in their ability to detect eye direction, which improves by early adolescence (Webster & Potter, 2008). Thus, individuals affected by an ASD are not aware of gaze cues during their daily communicative exchanges, which are crucial for establishing a shared awareness that is fundamental to joint attention development.

*The development of gaze monitoring.* Although the functional development of direct eye gaze is an under-researched area in the autism literature, there is an impressive body of work regarding the attention cueing and gaze monitoring skills of individuals with an ASD. First, it will be helpful to differentiate between two types of gaze following put forth by Driver and colleagues (1999): mechanical gaze following versus mentalistic gaze following. In particular, *mechanical* gaze following refers to basic perceptual gaze discrimination skills, which are typically elicited in reflexive visual orienting paradigms, whereas *mentalistic* gaze following is a voluntary shift in attention, which requires an appreciation that eye gaze is an index of another person's focus of attention or interest (Vlamings, Stauder, van Son, & Mottron, 2005). This is an especially important distinction in the case of autism where children have an intact ability to compute the direction of eye gaze (i.e., mechanical gaze following), but fail to understand that gaze represents another's mental state (i.e.,



mentalist gaze following; Leekam et al., 1997)

Several studies have used observational methods to investigate the nature of gaze following deficits in ASD. For example, Leekam et al. (1997) observed that children with autism fail to spontaneously monitor an adult's head and eye movements in comparison to participants with Down syndrome and typical development. Children with an ASD were only successful during tests of gaze direction discrimination when they were explicitly instructed to report on what another person was looking at. In a follow-up experiment, Leekam, Hunnisett and Moore (1998) observed that children with autism with a verbal mental age (VMA) above 4 years (mean age 8.5 years) were able to spontaneously follow the head turn and gaze of another, which was in contrast to the spontaneous gaze following abilities among the lower VMA group. Rather than impairment in gaze following, the authors suggest that children with an ASD are developmentally delayed in this behaviour (Leekam et al., 1998).

If children with an ASD are delayed in their spontaneous gaze monitoring, then it raises an important question of whether attention cueing in response to gaze shifts is intact in ASD, which is an attentional feature characteristic of typically developing infants. Posner-style spatial cueing paradigms are widely used in the literature to examine reflexive orienting. In these computer-based tasks, participants are initially presented with a directional cue that provides either valid or invalid information regarding the location of the target stimulus. Participants are typically faster at detecting targets in the valid cue condition, referred to as the validity effect.

The majority of studies using Posner-style paradigms have found that individuals with autism demonstrate the commonly reported validity effect to gaze cues in experimental studies. For example, Kylliainen and Hietanen (2004) confirmed that the static gaze direction of another person results in an automatic shift of attention among school-age children with HFA. In response to dynamic displays, school age children with HFA, 2-year-old children with an ASD, as well as their typically developing peers, also demonstrate the validity effect in response to perceived gaze shifts (Chawarska, Klin, & Volkmar, 2003; Swettenham, Condie, Campbell, Milne, & Coleman, 2003). The finding among 2-year-olds was especially intriguing given that the children were initially unsuccessful in a spontaneous gaze following scenario (Chawarska, et al., 2003). Although several authors argue that perceived motion in gaze cues contributes to attention shifts in autism, recent findings reveal that terminal eye direction directs reflexive attention shifts among adults with an ASD and with typical development (Rutherford & Krysko, 2008). Together, these findings indicate that difficulties in spontaneous gaze following in ASD are not the result of abnormalities in reflexive orienting to gaze cues (Chawarska et al., 2003).

Using simply drawn, static displays, Ristic and colleagues (2005) presented an interesting caveat to studies supporting the ability to process gaze direction in ASD. In typical development, eye gaze produces reflexive shifts of attention even when it is not informative or predictive of a stimulus location (Friesen & Kingstone, 1998). However, Ristic et al. (2005) observed that individuals with HFA use gaze direction as a statistical contingency between a

cue and a target, thus failing to demonstrate the validity effect when the cue is uninformative (50% trials cued correctly, 50% cued incorrectly). In a similar experiment, Goldberg et al. (2008) failed to find the validity effect with static line drawings of gaze among children with HFA. In fact, Goldberg et al. (2008) proposed that gaze cues influence voluntary shifts of attention in HFA, unlike in typical development where gaze shifts are reflexive in nature. Together, these findings suggest that individuals with an ASD may process gaze information differently than their typically developing counterparts, and thus fail to appreciate the social significance of eye gaze information (Ristic et al., 2005).

In line with this idea, a number of studies have demonstrated that individuals with an ASD are cued equally well by social (e.g., eye gaze) and non-social cues (e.g., arrows; Chawarsksa et al., 2003; Senju, Tojo, Dairoku, & Hasegawa, 2004; Vlamings et al., 2005), in contrast to typically developing individuals who demonstrate distinctive patterns of reflexive orienting to eye gaze. Subsequently, the manner with which individuals with an ASD process gaze information may be distinct from processes characterizing typical development. Although mechanical gaze following may be intact in ASD, gaze does not possess the same inherent social relevance characteristic of typical development. Given that reflexive orienting does not require an understanding of the representational content of a cue (Ames & Jarold, 2007), these results are consistent with impairments in mentalistic gaze processing in ASD. Throughout development, it is likely then that impairments in gaze processing impede the recognition of socially relevant information from faces (Adolphs, Sears, & Piven, 2001).

### *Implications of Gaze Processing Deficits to the Development of Face Processing*

In light of the evidence reviewed above, it is possible that the trajectory of gaze processing skills in autism contributes to the atypical manner with which individuals with an ASD process social and emotional information from faces. Using eye-tracking techniques, recent face processing research has revealed differences in the visual scanning paths among individuals with an ASD and typical development while viewing either static images of faces or dynamic social scenes. Unlike typically developing individuals who attend primarily to the eyes, individuals with an ASD demonstrate decreased fixation time to the eyes (Klin, Jones, Schultz, Volkmar, & Cohen, 2002a; Pelphrey et al., 2002; Trepagnier, Sebrechts, & Peterson, 2002) and attend preferentially to the mouth (Joseph & Tanaka, 2003; Klin et al., 2002a). During dyadic interactions with their mother, even 6-month-old high-risk infants were distinguishable from control infants because of diminished gaze to their mother's eyes relative to her mouth (Merin, Young, Ozonoff, & Rogers, 2007). These findings are consistent with evidence from emotion recognition tasks where participants with HFA make a greater number of fixations to the mouth and rely more heavily on information from the mouth region to recognize emotional expressions (Spezio, Adolphs, Hurley, & Piven, 2007b). In fact, Joseph and Tanaka (2003) propose that there may be an unusual privileging of the mouth region when individuals with an ASD process information from the faces of their social partners. Interestingly, Klin et al. (2002a) observed that increased fixation to the mouth was a strong predictor of social understanding in ASD, suggesting that individuals with HFA may

effectively use their linguistic strengths to scaffold their social understanding.

Although there are certain circumstances under which individuals with an ASD do not demonstrate atypical fixation patterns (e.g., van der Geest, Kemner, Camfferman, Verbaten, & van Engeland, 2002), face processing deficits typically appear when they are presented with images that are dynamic and social in nature (Rutherford & Towns, 2008; Speer, Cook, McMahon, & Clark, 2007). Thus, in real-life interpersonal communication, individuals with an ASD may not interpret or respond to the nonliteral aspects of communication that are portrayed by the eyes of their social partners (Sterling et al., 2008). These findings highlight the influence of an atypical developmental trajectory of gaze processing skills to later difficulties in perceiving social signals from faces.

In summary, there is considerable evidence that the underlying processes related to the development of gaze and face processing skills in ASD is not associated with an appreciation of the social salience of gaze. Specifically, young infants with an ASD demonstrate pervasive deficits in their dyadic reciprocity skills. Their early onset difficulties in attending to the faces of their social partners and engaging in mutual gaze compromises social learning opportunities, which typically provide the developmental building blocks for spontaneous gaze following, namely joint attention. Thus, in autism, delays in joint attention are attributable to difficulties in engaging at a dyadic level. Consequently, children with an ASD fail to appreciate the social significance of gaze, which has a lasting impact on their ability to attend to and acquire meaning from faces. From this perspective, a lack of sensitivity to mutual gaze early in life may be critical to

help explain the pathogenesis of autistic impairments in social communication.

### *The Present Study*

There are a growing number of studies related to the manifestation of social impairments characteristic of autism. These studies reliably indicate that difficulty in spontaneously monitoring another person's gaze is one of the most robust indicators of an ASD. It is important to note that in typical development, infants are sensitive to faces with eye contact, which is fundamental to their ability to follow gaze by 10- to 11-months of age. Although a considerable amount of attention has been given to the reflexive orienting and gaze monitoring abilities of children with an ASD, there are relatively few studies addressing the role of mutual gaze in social cognition among young children with an ASD. As a result, the objective of the current study was to examine the perception of different gaze directions among children recently diagnosed with an ASD between 2- to 4-years of age in relation to their level of developmental and social communication functioning.

The consensus among researchers is that children with an ASD are delayed rather than impaired in their spontaneous gaze monitoring skills (e.g., Leekam et al., 1998). At the same time however, the emergence of early shared attention skills in ASD follows a different developmental sequence in comparison to the pattern observed in typical development (Carpenter, Pennington, & Rogers, 2002). Collectively, this research suggests that mental and chronological age may be critical factors underlying the emergence of different stages of gaze processing in ASD. This may be especially relevant to the current investigation, which

includes children between 2- to 4-years of age with an ASD who may be heterogeneous in their preverbal social cognitive skills, and may demonstrate an uneven profile of social communicative behaviours.

To determine the nature of this relationship with respect to the perception of mutual gaze, children with an ASD between 2- to 4-years of age were compared to 2 groups of typically developing children, who were matched on either chronological or mental-age, using a novel, computerized paradigm, which required children to passively view faces with different gaze directions. The mental-age matched controls were included in the study to examine gaze perception among a group of children where joint attention is not fully consolidated. Due to the early onset social communicative difficulties in autism, it was predicted that children with an ASD would not demonstrate a specific preference for faces with either a direct or an averted gaze. Children with typical development may be sensitive to mutual gaze, regardless of age (Batki et al., 2000; Conty, Tijus, Hugueville, Coelho, & George, 2006). Subsequently, it was predicted that both groups of typically developing children would preferentially attend to faces with direct gaze. Finally, it was expected that each participant group would demonstrate unique profiles of viewing patterns because of their varying degrees of social cognitive development. As such, the relationships between fixation patterns and group membership, developmental level, and social competence were investigated.

## Method

### *Participants*

Forty-two participants (6 girls, 36 boys) were included in this study comprising three groups of children: one group of children diagnosed with an Autism Spectrum Disorder (ASD;  $n = 14$ ) was compared to two groups of typically developing children matched on gender and chronological (TDCA;  $n = 14$ ) or mental age (TDMA;  $n = 14$ ). The children with an ASD ranged in age between 25- and 44-months (mean  $CA = 34.07$  months,  $SD = 6.16$  months). Children with an ASD were recruited after they were seen for diagnostic purposes at the Autism Spectrum Disorder Clinic at the Montreal Children's Hospital. All children with autism received a diagnosis by experienced clinicians based on observation and parental report from the Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, DiLavore, & Risi, 1999) and the Autism Diagnostic Interview-Revised (ADI-R; Lord, Rutter, & LeCouteur, 1994). The final clinical sample was comprised mainly of children diagnosed with Autistic Disorder ( $n = 12$ ) as well as PDD-NOS ( $n = 2$ ). Children with typical development ranged between 6 to 48 months (TDCA: mean  $CA = 35.93$  months,  $SD = 6.35$ ; TDMA: mean  $CA = 14.21$  months,  $SD = 4.48$ ) and were recruited via advertisements in English based family newspapers and word of mouth in Montreal and Toronto. All typically developing children had hearing and vision within normal limits and did not present with any medical conditions. Parents did not report any concerns on the Ages and Stages Questionnaire (ASQ; Squires, Potter, & Bricker, 1999), which is a developmental screener used to identify problems in the areas of communication, motor, problem solving, and personal-social skills. Overall, the groups were similar in ethnic distribution such that the vast majority in each



group were Caucasian (ASD: 71%; TDCA: 66%; TDMA: 85%). The ASD group was slightly more heterogeneous with approximately 28% of children from different ethnicities: Arab/west Asian, African, Asian, and mixed backgrounds (i.e., Caucasian and Arab/west Asian), whereas children from different ethnic backgrounds represented 23% of the children with typical development (i.e., Chinese or mixed ethnicities such as Caucasian and Asian or Caucasian and East Indian). All families spoke English in the home except one family in the clinical group who spoke Mandarin. Seven families in the clinical group also reported speaking a second language in the home, which was typically French.

*Matching Procedure.* In their meta-analysis of research related to the social cognitive abilities of individuals with an ASD, Shaked and Yirmiya (2004) highlighted that smaller between group differences emerge when participants are matched on a one-to-one basis. As a result, typically developing children were recruited in an effort to individually match them to participants in the clinical group on gender and either chronological (CA) or mental age (MA). In the latter case, participant matching was based on mental age equivalents derived from the Mullen Scales of Early Learning (MSEL; Mullen, 1995). Furthermore, our matching analysis was completed according to criteria put forth by Mervis and Klein-Tasman (2004), who recommend a  $p$  level of at least .50 to demonstrate that groups strongly overlap on the control variable, whereas a  $p$ -value less than .20 indicates that groups are not well matched.

As expected, there were significant differences across the three groups in terms of overall MA, nonverbal (NVMA) and verbal mental ages (VMA). Post

hoc comparisons using a Bonferroni correction revealed that the chronologically matched controls had higher overall MAs ( $p < .01$ ) and VMAs ( $p < .01$ ) than both the ASD and TDMA groups. As a result, children were well matched on the measure of prelinguistic and verbal receptive and expressive skills (i.e., VMA) and minimally matched on overall mental age, according to Mervis and Klein-Tasman's criterion. The former result is especially relevant to the present investigation as language development is theoretically linked to an infant's sensitivity to gaze directions (Morales, Mundy, & Rojas, 1998). Children with an ASD had significantly lower NVMA scores than their CA matched controls, as well as higher NVMA scores than their MA matched controls. This difference is likely due to developmental constraints among the typically developing MA matched controls who were significantly younger than the ASD group. See Table 1 for participant characteristics.

### *Measures*

All participants were administered a battery of measures designed to independently assess developmental level as well as social competence, and to determine if children orient preferentially to faces with specific gaze directions.

*Developmental measure.* The MSEL is an individually administered standardized developmental assessment designed for children from birth to 68 months. The MSEL provides summary scores and corresponding developmental ages according to 5 scales, four of which assess cognitive ability: visual reception, fine motor, and receptive and expressive language. The MSEL demonstrates strong concurrent validity with other developmental batteries (Mullen, 1995). All

participants were administered the MSEL by a graduate student with extensive experience in psychological testing and with children with an ASD.

*Adaptive functioning.* The Vineland Adaptive Behaviour Scales, Second Edition (VABS-II; Sparrow, Balla, & Dominick, 1984) was used to assess level of adaptive behaviour. Adaptive behaviour reflects an individual's competence in meeting both independence needs and social demands of the environment. The VABS is a parent interview that provides measures of adaptive behaviours in four domains: communication, daily living skills, socialization, and motor skills, which yield an overall adaptive behaviour global composite. The VABS consists of 297 items that are administered to a parent or caregiver in a semi-structured interview format. The variables of interest for the current project included the socialization and communication domain scores.

*Eye gaze stimuli.* To determine children's viewing patterns for specific gaze directions the newly developed *Eye Gaze Preference Task* was designed based on paradigms frequently used in gaze perception studies (e.g., Farroni et al., 2002; Farroni, Johnson, & Csibra, 2004; Grice et al., 2005). Experimental stimuli were four different front-view faces (2 female, 2 male) presented on a grey background with their gaze either directed straight-on to the viewer (i.e., direct gaze), averted to either the left or right (i.e., averted gaze), or with the eyes closed. The stimuli were created using Adobe Photoshop PS2 software so that different gaze directions could be superimposed on the same basic image for each face type. In doing so, all elements of the face were held constant except for the gaze direction. In total, 16 stimuli (4 faces x 4 gaze directions) were used in the

study (see Figure 1).

The experiment was run on a Toshiba with a 17-inch monitor using Superlab 4.0 software. Children passively viewed faces on the computer screen while seated on their caregivers lap or alone on a chair approximately 90 cm from the screen. First, children were presented with 3 practice trials of cartoon images to attract their attention to the computer screen. The experimental portion of the task consisted of 2 conditions with 16 trials each. The order of conditions was counterbalanced and the order of trials within each condition was randomly distributed. A blank screen separated the conditions in case the child required a break. Each trial began with a centrally located probe to direct the child's attention to the computer screen. In the *2-face condition*, the child was presented with two pictures of the same face with eyes closed. When the examiner judged that the child was centrally fixated on the screen, the gaze direction of the faces changed from eyes closed to one face with direct gaze and the other with the gaze averted to either the left or the right. Stimuli were located to the left and the right of the central axis of the screen and the location of the direct and the averted gaze directions was counterbalanced. The stimuli remained on screen for 5000 milliseconds. In the *1-face condition*, when the probe was eliminated, the display changed to one of the stimuli (i.e., direct, averted left, averted right, closed), which remained on screen for 5000 milliseconds. In both conditions, the inter-stimulus interval was variable and ranged between 500-1500 milliseconds.

Separate videos of the child and the computer screen were recorded using a Microsoft webcam VX-6000 and a Sony digital recorder. Using Pinnacle Studio

10 software, videos were viewed simultaneously and edited together to superimpose images of the child onto the video footage from the computer screen (see Figure 2). This process was completed on a frame-by-frame basis (30 frames/second) so that the first frame of detectable deviation of a child's gaze shift could be established for coding purposes. A sound cue, which provided digital information within each frame, was used to ensure the synchronization between the videos of the child and the computer screen. Performance was recorded in terms of percentage of fixation time, mean first fixation, and the number of orienting responses according to each gaze direction.

The performance data were coded from the videotapes by the lead author on a frame-by-frame basis. A second coder, blind to the diagnosis of children in all cases, coded 25% of the videotapes for reliability purposes. The intraclass coefficients (ICCs) for each of the performance variables were generally good to excellent (see Table 2). In the 2-face condition, ICCs ranged from .62 (mean first fixation to direct gaze) to .97 (percentage of time fixating on direct gaze) and in the 1-face condition ranged between .92 (percentage of time fixating on faces with eyes closed) and .97 (mean first fixation to direct gaze).

### *Procedure*

The current project was conducted with approval from the McGill University Ethics Committee (see Appendix A). Families of children with an ASD were participating in an ongoing randomized control study conducted at the ASD clinic in the Montreal Children's Hospital and were recruited for the current study (please see Manuscript 2 for details). Families of typically developing

children who contacted the lead author were sent an information sheet outlining the research objectives and procedural requirements involved in the study. Informed consent was obtained from each family to participate in the current project. When appropriate, children were explained the purpose and procedures of the study using developmentally appropriate language, and only those who verbally assented to participate were included in the study. Children with an ASD were seen at the Montreal Children's Hospital and the typically developing children were seen at their home or the McGill Child Laboratory for Research and Education in Developmental Disorders. Children participated for approximately one hour to complete the developmental assessment and the Eye Gaze Preference Task. The adaptive interview and developmental screener were then administered to parents, while their child played. When required, participants received breaks at various points during the visit.

## Results

Data were examined using the Statistical Package for the Social Sciences (SPSSv.12.0). Descriptive statistics (i.e., mean, standard deviation) were computed across all measures. Parametric inferential statistics (i.e., ANOVA, repeated measures MANOVA) were used to test for significant differences in scores on measures of developmental and social functioning, as well as on performance during the Eye Gaze Preference Task. These analyses were followed up by a discriminant function analysis to examine the between group separation across the set of dependent variables. Finally, a series of bivariate correlations were used to explore the relationship between performance on the Eye Gaze

Preference Task and outcome measures of social competence and developmental functioning.

### *Developmental Functioning*

Separate analyses of variance (ANOVA) were computed to examine differences in cognitive functioning across groups. To do so, developmental quotients were calculated according to individual mental age scores derived from the MSEL. The developmental quotient for overall functioning (ODQ) was calculated as follows:  $ODQ = (\text{overall MA/CA}) \times 100$ . Verbal (VDQ) and nonverbal (NVDQ) developmental quotients were calculated in the same manner. Ratio IQ scores were calculated rather than using standard scores from the MSEL to avoid floor effects (i.e., children's standard scores are overestimated if their performance is at the floor of the scaled score). These tests revealed significant differences across the three groups in terms of their overall ODQ ( $F(2,39) = 81.472, p < .01$ ), verbal (VDQ:  $F(2, 39) = 65.523, p < .01$ ), and nonverbal functioning (NVDQ:  $F(2, 39) = 26.293, p < .01$ ). To examine group differences, post hoc comparisons were completed with a significance level of  $p < .05$ . While preliminary analyses addressing the distribution of scores revealed unequal variances across groups, the Games-Howell statistic for unequal variances was used in the subsequent analyses. These comparisons revealed that both groups of typically developing children had significantly higher developmental quotients across all three domains than the children diagnosed with autism, whereas no significant differences existed between the means of the chronological and mental-age matched controls (see Table 3). These findings are not surprising as

the majority of the children with an ASD performed well below the average range of functioning across all subtests of the MSEL.

### *Social Functioning*

Separate ANOVAs were computed to examine differences in social competence across groups. Indices of social competence were defined by level of social adjustment (SOC) and communicative ability (COM; i.e., the former operationalized as the standard score on the socialization domain and the latter on the communication domain of the VABS-II). These tests revealed significant differences across the three groups in terms of their social adjustment ( $F(2,39) = 92.509, p < .01$ ) and communicative ability (COM:  $F(2, 39) = 52.443, p < .01$ ). Bonferroni post-hoc comparisons revealed that both groups of typically developing children had significantly higher levels of social competence than the children with an ASD ( $p < .01$ ), whereas no differences were revealed between the two groups of typically developing children (see Table 4).

### *Performance on the Eye Gaze Preference Task*

*Preliminary analysis for the 2-face condition.* Prior to conducting group comparisons for performance variables from the 2-face condition, several tests of assumptions associated with repeated measures design were completed across the distribution of scores. In assessing univariate normality, the analyses indicated that the distribution for orienting responses to averted faces in the ASD group was significantly platykurtic according to the Shapiro-Wilk test statistic ( $S-W = .864, p < .05$ ). While a single kurtotic variable can have a slight effect on power, repeated measures analyses are robust against violations of multivariate



normality. This departure from normality may however be biasing Box's test statistic, which indicates that the repeated measures analysis violates the assumption of homogeneity of covariance matrices ( $p < .01$ ). Nevertheless, the test statistic is robust when group sizes are equal. Finally, the assumption of sphericity (i.e., the equality of variances of the difference between pairs of the within-subject variable) was not a necessary condition for the current analysis, which is qualified by a single within-subject variable with only 2 levels.

*2-face condition.* To establish whether differences existed in children's fixations toward faces with different gaze directions, performance on the Eye Gaze Preference Task: 2-face condition was compared across groups. This was achieved by computing a repeated measures Multivariate Analysis of Variance (MANOVA) with gaze (direct vs. averted) as the within-subject variable and group as the between-subject variable. To review, performance variables in the 2-face condition were defined as the mean length of the first fixation, the number of orienting responses, and the percentage of time spent fixating on faces.

For the current multivariate analysis, the  $F$ -value associated with Wilks  $\Lambda$  was used to examine the relationships among the variables. In particular, there was a significant multivariate main effect of group,  $F(6, 74) = 3.547, p < .01$ . Univariate results of the between-subject main effect indicated that all the dependent variables were significantly contributing to the overall multivariate significance. There was no significant within-subject main effect of gaze ( $F(3,37) = .605, ns$ ), indicating that performance was generally the same across direct and averted gaze directions. There was also no significant interaction between gaze

and group ( $F(3, 37) = .544, ns$ ), which suggested that performance was not variable within each group as a result of different gaze directions. These findings indicate that a significant difference was observed across groups in terms of children's likelihood to orient toward and fixate on faces in general, irrespective of gaze.

To understand the between-subject main effect of group, Tukey's post-hoc comparisons were computed on each of the dependent variables. The mean performance data associated with these pairwise comparisons are presented in Table 5. These tests revealed that the MA matched controls demonstrated significantly longer first fixations than the chronological matched controls and children with an ASD (see Figure 3). Children diagnosed with an ASD demonstrated significantly fewer orienting responses than both groups and spent significantly less time fixating on faces than their chronological controls (see Figure 4). Together, these results indicate that each group was unique in the manner with which they attended to faces during the Eye Gaze Preference Task. To illustrate this finding, children's first fixation was converted to the percentage of time accounted for by their first fixation (i.e., first fixation time/total fixation time; see Figure 5). This variable was only marginally significant across groups ( $F(2,39) = 2.88, p > .06$ )

*Preliminary analysis for the 1-face condition.* Similar to the previous analysis, the appropriate tests were computed to assess whether the distribution of scores within each group violated any of the assumptions associated with a repeated measures MANOVA. Although there were no significant departures

from univariate normality across the dependent variables, Box's test statistic was significant at the  $p < .05$  level, which indicates that the repeated measures analysis violates the assumption of homogeneity of covariance matrices. Finally, Mauchley's test indicated that the assumption of sphericity was not violated by the current analysis, which demonstrates that the variances of the difference between pairs of the within-subject variable were equivalent (i.e., the within-subject variable was characterized by 3 levels in the 1-face condition).

*1-face condition.* To establish whether differences existed in children's preference for a specific gaze direction, performance on the Eye Gaze Preference Task: 1-face condition was compared across groups. This was achieved by computing a repeated measures MANOVA with gaze (direct vs. averted vs. closed) as the within-subject variable and group as the between-subject variable. Performance variables in the 1-face condition were defined as the mean length of the first fixation and the percentage of the time spent fixating on faces. The total number of orienting responses was not included as a dependent variable in this condition as there was no attention-shifting component during the task.

For the current multivariate analysis, the  $F$ -value associated with Wilks  $\Lambda$  was used to examine the relationships among the variables. There was a significant multivariate main effect of group,  $F(4, 76) = 2.830, p < .05$ . However, univariate tests of the between-subject main effect revealed that only the percentage of time spent fixating on faces ( $F(2, 39) = 3.48, p < .05$ ) was contributing to the overall multivariate significance. Bonferroni post-hoc comparisons were computed to understand the between-subject main effect of

group on the amount of time spent fixating on faces. These tests revealed that children diagnosed with an ASD ( $M = 57.88$ ,  $SD = 18.18$ ) spent significantly less time fixating on faces than the CA matched controls ( $M = 74.08$ ,  $SD = 10.71$ ;  $p < .025$ ), but not in comparison to MA controls ( $M = 65.95$ ,  $SD = 18.05$ ; see Figure 6). The difference in the amount of time spent fixating on faces was also not significant between the MA and CA controls.

A main effect of the within-subject variable gaze ( $F(4, 36) = 2.83$ ,  $p < .05$ ) was also identified in the multivariate analysis. Additional univariate test results were in agreement with the multivariate analysis. These results suggested that there were significant differences in the mean first fixations and in the percentage of time spent fixating on faces when children were presented with different gaze directions. There was not however a significant interaction between gaze and group ( $F(8, 72) = 1.01$ ,  $ns$ ), indicating that performance was not variable within each group as a result of different gaze directions.

Within-subject contrasts were generated to delineate the main effect of gaze described above. In particular, a simple contrast was used to compare the means associated with either direct or averted gaze directions and with the eyes closed. These tests suggested that performance was significantly different across the dependent variables according to stimulus type (see Figure 7). Visual inspection of Figure 7 reveals that children demonstrated longer mean first fixations for the faces with eyes closed ( $M = 3162.30$ ,  $SD = 1383.96$ ) than for faces with either a direct ( $M = 2635.71$ ,  $SD = 1336.60$ ) or an averted gaze ( $M = 2521.24$ ,  $SD = 1037.48$ ). With respect to amount of fixation time, children looked

significantly longer at faces with the eyes closed than with the gaze averted; however, there was no difference in percentage of time spent viewing faces with the gaze directed or with eyes closed. Thus, faces with the eyes closed resulted in significant fluctuations across performance on the Eye Gaze Preference Task: 1-face condition. Interestingly, Figure 6 also illustrates that children rarely remained fixated for the entire duration of each stimulus display and they generally never made successive fixations during the same trial (i.e., there were only a few occurrences when a child reoriented their attention back to the same stimulus picture).

*How is Group Classification Discriminated by Children's Patterns of Attention To Faces during the Eye Gaze Preference Task?*

The repeated measures MANOVA on the Eye Gaze Preference Task: 2-face condition indicated a significant difference between groups when the dependent variables were considered simultaneously. Although subsequent post-hoc tests revealed distinct differences between groups, these univariate analyses did not account for the unique relationships existing between the dependent variables. As a result, a discriminant function analysis (DFA) for the 2-face condition was computed to investigate how a linear combination of the dependent variables discriminated the groups. This analysis was not completed for the 1-face condition because post-hoc analyses indicated that only one of the dependent variables was contributing to the overall multivariate effect of group. Although in the current analysis, groups differed in their covariance matrices (i.e., a significant Box's test statistic), DFA is robust when this assumption is not met provided group sizes are equal. Although the sample size is small for a DFA, the study is

exploratory in nature, and as a result, the findings are considered preliminary.

The findings of the DFA showed two functions in combination, referred to as function 1, significantly discriminated the groups (Wilks  $\Lambda = .516, p = .02$ ) and accounted for 57.9% of the variance in group separation. Function 2 alone did not significantly discriminate between groups (Wilks  $\Lambda = .751, p = .064$ ). This result suggests that group differences shown by the MANOVA can be understood in terms of one underlying dimension. When the unstandardized canonical discriminant function was evaluated as category means, function 1 was shown to discriminate participants with an ASD ( $M = -.82$ ) from both groups of typically developing children (MA:  $M = .052$ ; CA:  $M = .769$ ). The structure matrix was next examined to understand the relative contribution of each dependent variable to the discriminant function (i.e., these values are comparable to factor loadings in factor analysis). These correlations indicated that the percentage of fixation time and orienting responses to an averted face (correlations of .824 and .768, respectively) had high loadings onto the function, with the percentage of fixation time and orienting responses to the direct face (correlations of .442 and .557, respectively) secondarily involved. The standardized canonical discriminant function coefficients (i.e., partial correlations) were then used to assess the importance of each dependent variable's unique contribution to function 1. These coefficients indicated that the percentage of time fixating on averted and direct faces had a similarly large contribution to the function (coefficients of 1.03 and -.78, respectively), but that orienting responses to averted and direct faces were redundant given the other variables in the set (coefficients of .54 and .14

respectively). The fact that the dependent variables were opposite in weight indicates that group separation is explained by the difference between the dependent variables. Thus, combining the information from above, it is clear that the groups differed mainly along one underlying dimension, which was characterized by the amount of time participants fixated on faces.

*Relation between Developmental Functioning, Social Competence and Face Fixation*

As previously mentioned, groups significantly differed in their developmental and social functioning, as measured by their skill level on the MSEL and VABS-II respectively. In particular, post hoc comparisons revealed significant mean differences between the group of children diagnosed with an ASD and typically developing controls across both areas of functioning. These results raise the possibility that the variability across groups in developmental level and/or degree of social competence may be related to children's performance on the Eye Gaze Preference Task. To explore the extent to which these variables accounted for the variance in children's likelihood to fixate on faces, a series of bivariate correlations were computed according to group classification and task performance.

*2-face condition.* Bivariate correlations were computed according to group membership between verbal (VDQ) and nonverbal functioning (NVDQ), as well social adjustment (SOC) and communicative ability (COM), with children's percentage of time fixating on faces with direct (PCNTD) and averted (PCNTA) gazes. The PCNTD and PCNTA variables were selected due to results from the previous DFA for the 2-face condition. In particular, the DFA indicated that group

separation was most parsimoniously explained by differences in the percentage of time spent fixating on faces. Finally, these correlations were computed according to group separation identified by the significant discriminant function (i.e., TD vs. ASD).

As can be seen in Table 6, measures of developmental and social functioning were not associated with performance on the Eye Gaze Preference Task when children were presented with 2 faces simultaneously. These findings establish that verbal and nonverbal ability, as well as level of social adaptation and communicative skill have no predictive association with fixation time on faces over and above group classification (i.e., TD vs. ASD). Therefore, a point-biserial correlation was computed to determine the predictive association between group membership and the percentage of time children fixated on faces. This analysis revealed a significant relationship between group membership and PCNTA ( $r_{pb} = -.463, p < .01$ ), but not with PCNTD ( $r_{pb} = -.293, p = .06$ ). As a result, group membership accounted for 21.4% ( $R^2 = (.463)^2 = .214$ ) of the variability in the amount of time children fixated on faces with an averted gaze.

*1-face condition.* Bivariate correlations were computed according to group membership between verbal (VDQ) and nonverbal functioning (NVDQ), as well as social adjustment (SOC) and communicative ability (COM), with children's percentage of fixation time on faces with direct (PCNTD) and averted (PCNTA) gazes, as well as eyes closed (PCNTC). The variables associated with the percentage of time fixating on faces were selected due to earlier analyses, which indicated a significant effect of group exclusively related to the aforementioned



dependent variables. Furthermore, several within-subject contrasts yielded significant effects related to the manipulation of stimulus type on performance during the Eye Gaze Preference Task: 1-face condition. As a result, these dependent variables best depicted the relationship between stimulus manipulation and task performance. Unlike the previous correlational analysis, the correlations below were computed according to the original group classification (i.e., MA, CA, and ASD).

Measures of developmental functioning and social competence were not significantly related to performance among typically developing children when they were presented with one face. Indices of communicative skill and social adjustment were related to performance among children diagnosed with an ASD across gaze directions on the Eye Gaze Preference Task (see Table 7). In particular, positive correlations were observed between level of communicative skill and the percentage of time spent fixating on faces with the gaze directed ( $r = .624, p < .05$ ), averted ( $r = .762, p < .01$ ), and with eyes closed ( $r = .804, p < .001$ ), as well as between level of social adjustment and faces with eyes closed ( $r = .620, p < .05$ ). Thus, social competence, especially communicative skill, was a strong predictor of the percentage of time spent fixating on faces among children diagnosed with an ASD (PCNTD:  $R^2 = 38.9\%$ , PCNTA:  $R^2 = 58\%$ ; PCNTC: COM  $R^2 = 64.6\%$ , SOC  $R^2 = 38.4\%$ ). Unlike their typically developing controls, these results also suggest that the nature of the task changed for children with an ASD when they were presented with one face, rather than when they were presented with two competing stimuli.

## Discussion

The current project investigated whether young children newly diagnosed with an ASD demonstrated atypical responses to different gaze directions within the context of their developing social cognitive skills. While viewing static images of human faces, we found significant differences in average first fixations, number of orienting responses and percentage of visual fixation time on faces between children with an ASD and their chronological and mental-age matched controls. Unexpectedly, group differences were not influenced by the manipulation of gaze direction, and instead were strictly related to children's tendency to orient and fixate on faces in general. Thus, the current experiment provides evidence for atypical patterns of visual attention to faces in young children with autism.

As expected, children with an ASD did not demonstrate a preference for faces with direct or averted gaze. When children were presented with 2-faces, 2- to 4 year-old children with an ASD demonstrated a distinct profile of fixation responses toward faces. In comparison to their mental-age matched controls, children with an ASD demonstrated shorter initial fixations and fewer orienting responses. This latter result was also true in comparison to their chronological matched controls. As a result, children with an ASD spent less time fixating on faces across trials in comparison to typically developing children of the same age, which was also consistent with their performance during the 1-face condition. Together, these results provide novel insight into the manner with which young children with an ASD engage with faces.

Findings from a number of studies are consistent with current results. In particular, numerous researchers have speculated that children with an ASD are selectively impaired in their ability to attend to social stimuli (Dawson et al., 1998; Sasson, 2006). Although the current project did not compare performance across social and non-social stimuli, it helps fine-tune our understanding of the way in which young children with an ASD attend to social stimuli, specifically faces. Indeed, our results indicate that even from a young age, children diagnosed with an ASD respond differently than their typically developing counterparts when they visually attend to faces. Future studies are required that include comparisons to non-social stimuli to determine whether children have atypical visual fixation patterns that are specific to social stimuli.

It is also possible that our results can be explained by impairments in executive functioning in autism (e.g., Hill, 2004). In particular, the 2-face condition required participants to disengage and shift their attention between competing stimuli. Consequently, difficulties among children with an ASD in attending to the Eye Gaze Preference Task when they were presented with two faces may reflect more general problems in disengaging and shifting attention. It is however noteworthy that findings from the discriminant function analysis revealed that children with an ASD were distinguished from children with typical development by their tendency to attend to faces. Furthermore, children with an ASD demonstrated comparable performance when they were presented with only one face. Thus, not only are these findings consistent with early clinical observations of children with an ASD, but add to our growing knowledge as to

the nature of this impairment.

Currently, face processing research is focused on identifying the processing strategies employed by individuals with an ASD, in light of research that does not unequivocally support impaired performance during tests of face and emotion recognition in autism (Boraston & Blakemore, 2007). Findings from the current study indicate that both children with an ASD and with typical development did not demonstrate a preference for specific gaze directions. However, a more in-depth analysis of their response patterns yielded important differences in their performance, particularly during the 2-face condition. Although both groups of typically developing children differed significantly in their initial fixations, typically developing children switched their attentional focus more frequently between faces, and subsequently were more engaged by the facial stimuli, as reflected in their fixation time on faces. In contrast, children with an ASD seemed less interested in the task, which was evidenced across performance variables. Similarly in eye-tracking studies, high functioning adults demonstrate decreased fixation time to facial features or to faces in general in comparison to controls (Pelphrey et al., 2002; Trepagnier et al., 2002). Future studies combining eye-tracking technology with the current methodology are needed to clarify the processing strategies employed by children during the Eye Gaze Preference Task, such as the individual facial features children attend to while viewing the faces.

Previous face processing research presented by Klin et al. (2002a) identified that individuals with HFA who attended more to the mouth region of

faces also have higher scores of social competence. Further, Klin, Jones, Schultz, Volkmar, and Cohen (2002b) speculated that individuals with HFA use linguistic means to scaffold their social understanding. In the current study, there was a strong predictive association among children with an ASD between the amount of time fixating on faces that were presented singularly and children's communicative ability. More specifically, this result suggests that children who fixated longer on faces also demonstrated stronger receptive and expressive language skills. Although it is unclear which facial features children attended to in the current study, this finding suggests that even young, less able children with an ASD may rely on verbal means to make sense of their social world. The absence of a predictive relationship among the control groups is likely due to the lack of variability in communication skills within each group of typically developing children. Thus, the pairing of eye-tracking measures with the current task represents a relevant avenue for future research.

As previously noted, Leekam and colleagues (1998) proposed that both chronological and mental age influence the development of gaze monitoring in children with an ASD. In an extension of this hypothesis, our results suggest that these criteria may be relevant to children's ability to attend to faces in general. However, it remains unclear whether this is true for the development of mutual gaze as well. Our prediction that typically developing children would preferentially attend to faces engaged in direct eye contact was not supported by the current results. This finding seems contradictory in light of numerous studies that demonstrate typically developing individuals are uniquely sensitive to direct

gaze from birth onwards (Batki et al., 2000; Conty et al., 2006; Farroni et al., 2002; Senju et al., 2003). By 5-months of age, typically developing infants demonstrate an emerging understanding for the function of eye contact in interactive communication (Delgado, Messinger, & Yale, 2002) and continue to develop their social understanding of eye gaze well into early childhood. The typically developing children enrolled in the current project ranged in age between 6- and 48-months and are at various stages in development where they are learning about the communicative function of different gaze directions. Unlike gaze following paradigms, there is no communicative feature inherent to our task's design. Furthermore, the passive nature of our task not only limits comparisons with other studies, but also may not elicit sufficient attention from typically developing children, thus influencing their manner of responding (Grice et al., 2005). As a result, future studies that require active processing of gaze directions, such as those that include dynamic facial displays (Speer et al., 2007) or side-view faces with directed gaze (Conty et al., 2006), may better illustrate the developmental trajectory of mutual gaze among young children with an ASD.

More importantly however, the argument outlined above suggests that while both children with an ASD and typical development did not demonstrate a preference for either direct or averted gazes, this finding may potentially be explained by different underlying mechanisms. Using stimuli that closely resemble our own, Grice et al. (2005) explored the neural processing of eye gaze directions among children with an ASD ranging between 42- and 85-months of age while they passively viewed static images of human faces. Their results

indicated that the neural correlates of gaze processing among children with an ASD were enhanced by direct compared to averted gaze direction. Although previous studies reported similar patterns of neural activation among 4-month-old typically developing infants, age-matched and adult typically developing control groups did not demonstrate similar neural processing in response to eye gaze direction. Thus, Grice et al. (2005) suggested that the neural activation present among children with an ASD reflect a developmental delay in their neural architecture underlying gaze processing development. Even more, these findings may be representative of a lack of specialization within the social brain network for processes related to face and gaze processing in autism (Johnson et al., 2005).

The current study did not provide any behavioural evidence directly related to the processing of mutual gaze in ASD. However in combination with the results from Grice et al. (2005), it is possible that across groups children differentially processed gaze direction in a manner that was not captured by our task. Interestingly, the lack of sensitivity to gaze direction in the current project among typically developing participants was also observed by Grice et al. (2005) in the absence of enhanced activation to direct gaze among age-matched and adult controls. Thus, it is possible that the absence of sensitivity to gaze direction among 2- to 4-year-old children with an ASD in our study is reflective of early onset impairments in gaze processing, which has implications for the facilitation of neural circuitry typically associated with an ability to perceive social communicative signals conveyed by faces. This hypothesis can only be speculative and requires further study combining electrophysiological measures

with the Eye Gaze Preference Task to help clarify these relationships.

The present study addressed the role of mutual gaze in young children with an ASD. Neither children with autism nor typical development preferentially attended to either direct or averted gaze directions. However, our results highlight that children with an ASD demonstrate atypical patterns of visual attention to faces. Furthermore, the absence of sensitivity to mutual gaze among participants with an ASD in the current study may indeed be reflective of an atypical trajectory of gaze processing development. Future studies need to address the specificity of these results with other groups of children with atypical development to clarify the uniqueness of these impairments to autism. That is, are difficulties in visually attending to faces manifest in other children with developmental diagnoses other than autism? Moreover, a larger sample of children that can be stratified according to diagnostic category would be warranted to examine whether these deficits are universally present across the spectrum. Finally, the application of the Eye Gaze Preference Task with prospective studies of high-risk infants would help clarify the influence of social orienting impairments to the developmental trajectory of gaze processing skills. Taken together, results from these studies would indicate whether impairments in gaze processing are a primary deficit in ASD that lead to a disruption in the developmental processes instrumental to typical social communication.



Table 1

*Participant Characteristics (n = 42)*

|                      | ASD<br>(n = 14) | TDCA<br>(n = 14) | TDMA<br>(n = 14) |
|----------------------|-----------------|------------------|------------------|
| Chronological age    |                 |                  |                  |
| Mean (SD)            | 34.07 (6.16)    | 35.93 (6.35)     | 14.21 (4.48)     |
| Mental age           |                 |                  |                  |
| Mean (SD)            | 21.12 (8.10)    | 38.86 (7.38)     | 16.66 (5.09)     |
| Verbal mental age    |                 |                  |                  |
| Mean (SD)            | 19.07 (9.58)    | 40.54 (8.40)     | 17.07 (6.02)     |
| Nonverbal mental age |                 |                  |                  |
| Mean (SD)            | 23.18 (7.7)     | 37.18 (7.46)     | 16.25 (4.25)     |

Table 2

*Reliability analysis: Intraclass Correlation Coefficients (ICCs) for Performance Variables on the Eye Gaze Preference Task*

| Condition | Performance Variable          | Gaze Direction | ICCs |
|-----------|-------------------------------|----------------|------|
| 2-face    | First mean fixation           | Direct         | .62  |
|           |                               | Averted        | .63  |
|           | Number of orienting responses | Direct         | .89  |
|           |                               | Averted        | .75  |
|           | Percentage of fixation time   | Direct         | .97  |
|           |                               | Averted        | .83  |
| 1-face    | First mean fixation           | Direct         | .97  |
|           |                               | Averted        | .96  |
|           |                               | Closed         | .96  |
|           | Percentage of fixation time   | Direct         | .92  |
|           |                               | Averted        | .93  |
|           |                               | Closed         | .96  |

Table 3

*Mean Differences in Developmental Functioning across Participant Groups*

|      | TDMA    | TDCA    | ASD     |
|------|---------|---------|---------|
| ODQ  | 117.940 | 113.084 | 60.865* |
| VDQ  | 118.946 | 117.775 | 54.542* |
| NVDQ | 116.860 | 118.063 | 69.586* |

*Note.* *ODQ* = overall developmental quotient; *VDQ* = verbal developmental quotient; *NVDQ* = nonverbal developmental quotient.

\* $p < .01$ .

Table 4

*Mean Differences in Social Competence across Participant Groups*

|     | TDMA    | TDCA    | ASD     |
|-----|---------|---------|---------|
| SOC | 103.714 | 107.50  | 76.571* |
| COM | 107.286 | 114.571 | 77.571* |

*Note.* SOC = social adjustment; COM = communicative ability

\* $p < .01$ .

Table 5

*Group Differences among Performance Variables on the Eye Gaze Preference**Task: 2-Face Condition*

|                 | MA      | CA      | ASD     | Significant Mean<br>Difference |
|-----------------|---------|---------|---------|--------------------------------|
| First FT (msec) |         |         |         |                                |
| Mean            | 1939.77 | 1332.14 | 1404.64 | MA > CA**                      |
| SD              | 787.01  | 474.81  | 400.48  | MA > ASD*                      |
| Total OR        |         |         |         |                                |
| Mean            | 63.52   | 73.07   | 53.79   | MA > ASD**                     |
| SD              | 17.59   | 16.37   | 19.63   | CA > ASD**                     |
| FT on faces (%) |         |         |         |                                |
| Mean            | 73.71   | 82.11   | 62.13   | CA > ASD**                     |
| SD              | 16.88   | 16.57   | 25.8    |                                |

*Note.* FT = fixation time; OR = orienting response.

\*  $p < .05$ . \*\* $p < .025$ .

Table 6

*Simple Correlations according to Group Classification between Developmental Functioning, Social Competence and Fixation Time on Faces with Different Gaze Directions on the Eye Gaze Preference Task: 2-Face Condition*

|      | PCNTD |      | PCNTA |      |
|------|-------|------|-------|------|
|      | TD    | ASD  | TD    | ASD  |
| NVDQ | .336  | .254 | .131  | .30  |
| VDQ  | .021  | .213 | -.059 | .393 |
| SOC  | .097  | .086 | .191  | .208 |
| COM  | -.018 | .349 | .106  | .431 |

*Note.* *VDQ* = verbal developmental quotient; *NDQ* = nonverbal developmental quotient; *SOC* = social adjustment; *COM* = communicative ability; *PCNTD* = percentage of time fixating on direct gaze; *PCNTA* = percentage of time fixating on averted gaze.

Table 7

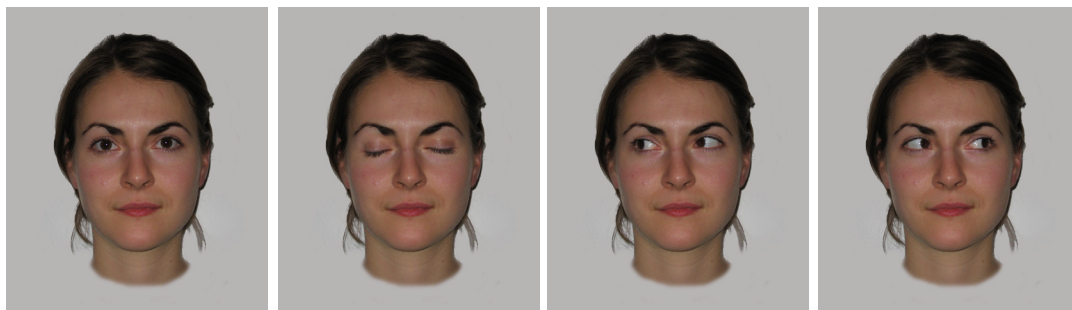
*Simple Correlations according to Group Classification between Developmental Functioning, Social Competence and Fixation Time on Faces with Different Gaze Directions on the Eye Gaze Preference Task: 1-Face Condition*

|      | PCNTD |       |       | PCNTA |       |        | PCNTC |       |        |
|------|-------|-------|-------|-------|-------|--------|-------|-------|--------|
|      | MA    | CA    | ASD   | MA    | CA    | ASD    | MA    | CA    | ASD    |
| NVDQ | -.278 | .313  | .363  | -.288 | .070  | .453   | -.391 | .322  | .307   |
| VDQ  | -.079 | -.090 | .237  | -.294 | .225  | .405   | .107  | .501  | .420   |
| SOC  | -.181 | .056  | .379  | .144  | .440  | .371   | .001  | -.225 | .620*  |
| COM  | -.254 | -.244 | .624* | -.091 | -.006 | .762** | -.038 | -.207 | .804** |

*Note.* *VDQ* = verbal developmental quotient; *NDQ* = nonverbal developmental quotient; *SOC* = social adjustment; *COM* = communicative ability; *PCNTD* = percentage of time fixating on direct gaze; *PCNTA* = percentage of time fixating on averted gaze; *PCNTC* = percentage of time fixating on faces with eyes closed.

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

*Figure 1.* Examples of stimuli: whole, front-view faces with direct, closed, averted left and right gaze directions.





*Figure 2.* Still-frame examples used for coding performance variables during the 2- and 1-face conditions. Simultaneous recordings of the computer screen were superimposed on to the video recordings of the child during the Eye Gaze Preference Task.

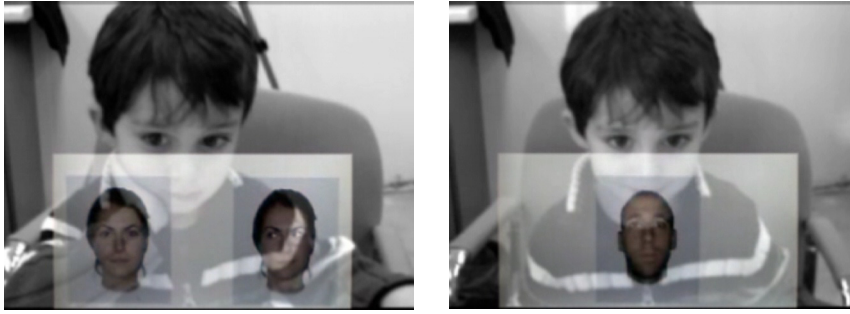


Figure 3. Mean first fixation time ( $\pm 1$  S.E.M) across groups.

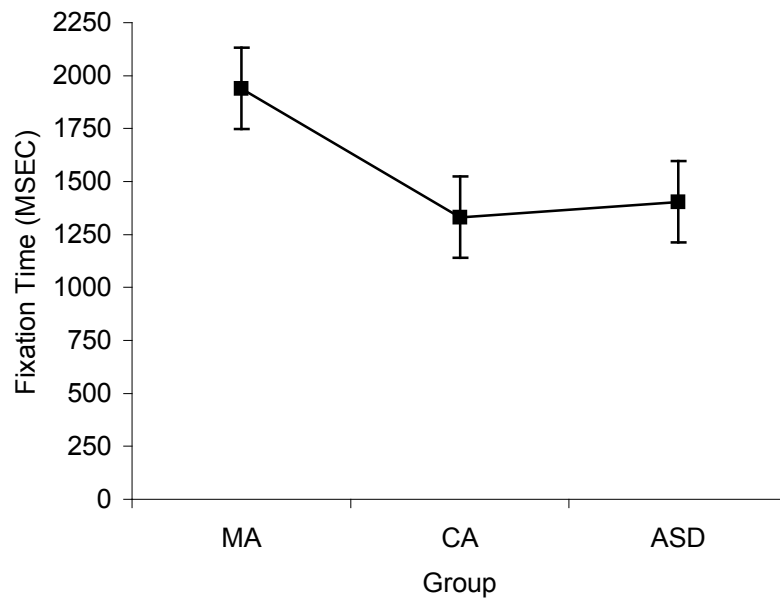


Figure 4. Total number of orienting responses (OR;  $\pm 1$  S.E.M.) and percentage of fixation time (FT) on faces ( $\pm 1$  S.E.M.) across groups.

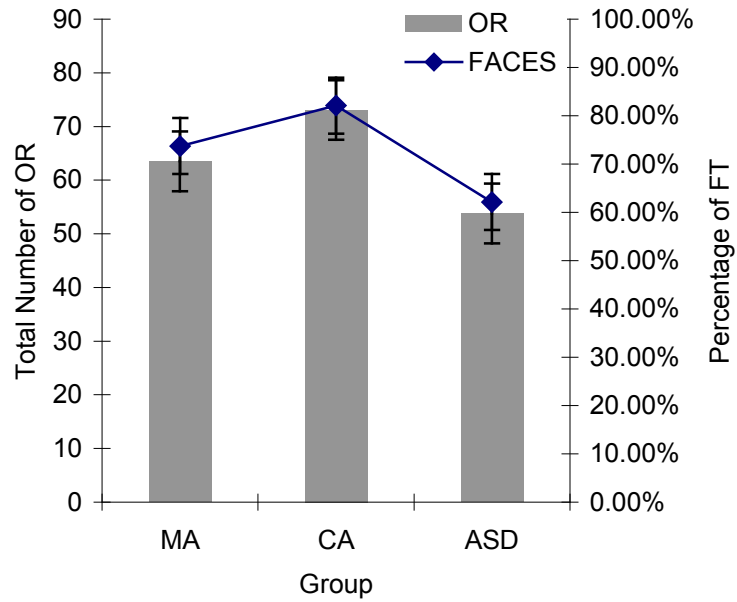


Figure 5. Profile of performance variables ( $\pm 1$  S.E.M) across groups.

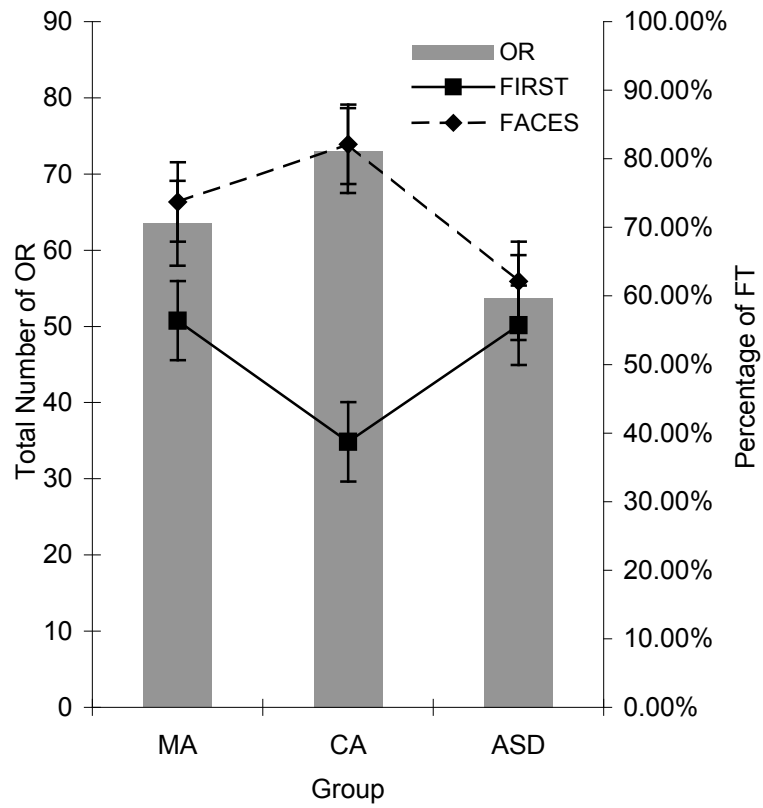


Figure 6. Percentage of fixation time on faces ( $\pm 1$  S.E.M) across groups.

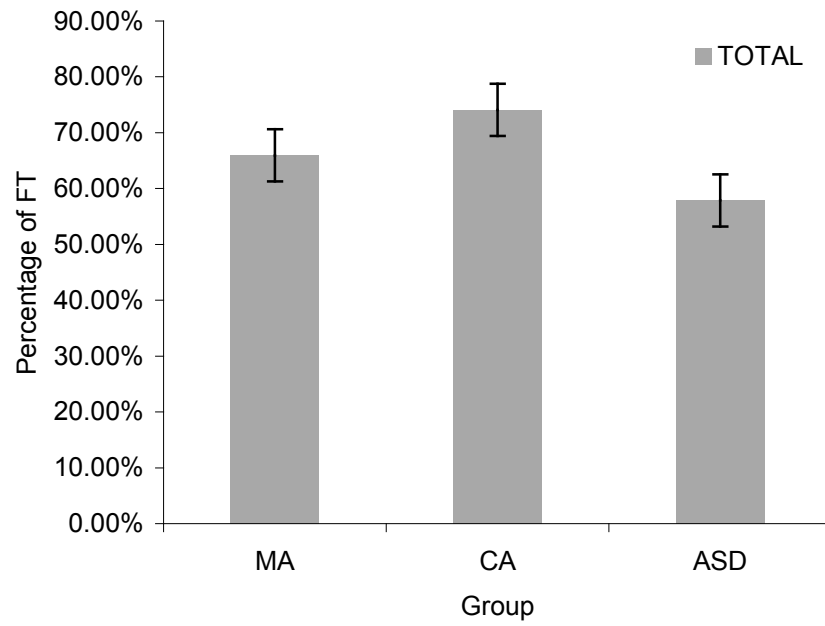
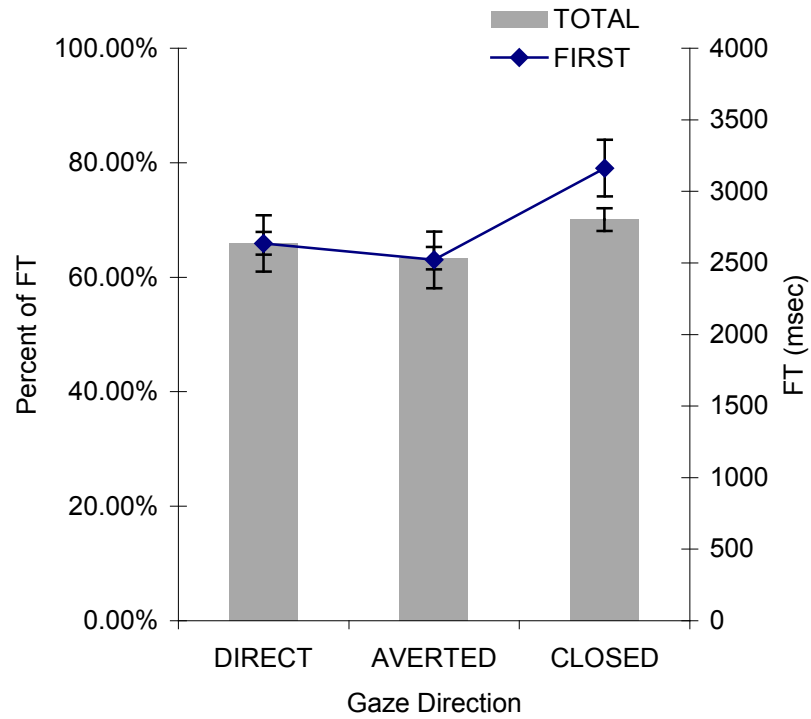


Figure 7. Mean first fixation time (FT;  $\pm 1$  S.E.M.) and percentage of fixation time (FT) on faces ( $\pm 1$  S.E.M.) across groups.



## TRANSITION TO MANUSCRIPT 2

It is important to delineate the manner and frequency with which young children with an ASD attend to faces to fully understand their contribution to more sophisticated social cognitive processes. Manuscript 1 piloted a computerized task to examine the gaze perception skills of children with an ASD in comparison to chronological and mental-age matched children with typical development. Although findings were not related to the manipulation of gaze direction, preschool children with an ASD were significantly less likely than their typically developing controls to attend and fixate on static images of human faces. These findings are consistent with both clinical and research observations, which document that inattention to faces is a symptomatic marker of ASD that emerges early in development and may persist into later childhood (Maestro et al., 2002; Osterling et al., 2002; Zwaigenbaum et al., 2005).

The pathogenesis of autism might in fact begin with an inability to interact with people at a dyadic level. In autism, atypical social communication may arise because basic dyadic reciprocity skills in infancy do not advance into more developmentally complex versions, such as joint attention, which is fundamental to the emergence of children's language and representational thought (Chawarska et al., 2007; Yirmiya & Ozonoff, 2007). Subsequently, early intervention approaches that encourage face-to-face reciprocal social interaction between children and their caregivers to support episodes of joint attention may contribute to dramatic changes in social communication among children with an ASD. In typical development however, an ability to initiate or respond to bids of joint

attention requires an appreciation of gaze direction. Thus, a question remains as to whether joint attention development coincides with changes in gaze perception among children with autism. Manuscript 2 examines this question using the newly developed Eye Gaze Preference Task within the context of a social communication intervention: are post-treatment changes in joint attention behaviours reflected in gaze processing skills among preschool children with an ASD?



MANUSCRIPT 2: NONVERBAL SOCIAL  
COMMUNICATION DEVELOPMENT AMONG PRESCHOOL  
CHILDREN WITH AUTISM SPECTRUM DISORDERS:  
PRELIMINARY FINDINGS FROM A RANDOMIZED  
CONTROL TRIAL OF A PARENT-TRAINING PROGRAM

## ABSTRACT

Delays in joint attention reflect impairments in dyadic engagement in autism. Although these deficits are well recognized, they are rarely the focus of intervention. The present report provides preliminary data from a randomized control trial of a parent-training program, which focuses on social engagement and joint attention development among young children with Autism Spectrum Disorders. A novel computerized task was piloted as an outcome measure of treatment effectiveness to examine changes in children's gaze perception skills. Among children in the treatment group, a non-significant trend emerged in their spontaneous viewing patterns for faces and joint attention skills. Findings are discussed in relation to early intervention approaches and support the development of the computerized task as a performance-based assessment tool.

## Introduction

Typically developing infants learn that gaze directions provide salient information about the communicative needs of their social partners. Among newborns, preferential attention to faces with direct gaze initiates a developmental sequence that enables gaze processing skills to evolve during the first year of life (Skuse, 2003). Consequently, dyadic interactions between infants and their caregivers provide the developmental origins for triadic joint attention behaviours (Striano & Rochat, 1999; Striano & Bertin, 2005). Therefore, difficulties in dyadic engagement may have far-reaching consequences for triadic interactive experiences and subsequent social communication development. For instance, in typical development extended periods of social interaction between infants and their caregivers provide scaffolding for language learning (Pruden, Hirsh-Pasek, & Golinkoff, 2006) and children's metacognitive growth (Carpendale & Lewis, 2004). Similarly, autism research identifies specific impairments in preverbal communication and joint attention skills, which are associated with delays in subsequent language and mentalistic understanding (e.g., Laing et al., 2002; Mundy & Burnette, 2005; Tager-Flusberg & Sullivan, 2000). Interestingly then, interventions embedded in enduring forms of interactions may be beneficial for the social and communicative development of children with an Autism Spectrum Disorder (ASD).

### *Relationship between Dyadic Engagement and Joint Attention in ASD*

Joint attention is a complex construct, which refers to a cluster of behaviours that share a common goal of communicating with another person in a

nonverbal manner (Bruinsma, Koegel, & Koegel, 2004). Joint attention appears in both responding and initiating forms across a variety of skills, which include attention following, social referencing, and showing or sharing objects of interest. Historically, autism research has focused extensively on the triadic quality of joint attention deficits to explain the manifestation of ASD, although relatively little research attention has addressed the developmental primacy of dyadic interaction (Leekam & Ramsden, 2006). This is especially intriguing given that difficulty engaging at a dyadic level is a defining diagnostic criterion among children with an ASD, who fail to look at the faces of their social partners and avoid eye contact (Leekam & Ramsden, 2006). Furthermore, children are only capable of engaging in episodes of triadic joint attention after they have displayed acts of dyadic social orienting, which refer to an ability to orient spontaneously to naturally occurring social stimuli in their environment (Dawson, Meltzoff, Osterling, Rinaldi, & Brown, 1998). In autism then, delays in joint attention may be attributable to difficulties in engaging at a dyadic level.

There are several recent studies that are supportive of this view, which are from two sources of empirical study. First, social attention research demonstrates that dyadic social orienting is predictive of an ability to respond to (Dawson et al., 2004; Leekam, Lopez, & Moore, 2000) or initiate episodes of joint attention (Dawson et al., 2004; Leekam & Ramsden, 2006;). Despite an intact ability to shift attention to a peripheral target (Leekam et al., 2000), children with an ASD demonstrate a specific impairment in their dyadic social orienting responses in comparison to mental-age matched controls with typical development (Dawson et

al., 2004) and with developmental delays (Leekam & Ramsden, 2006; Dawson et al., 2004; Leekam et al., 2000). Second, studies related to the nonverbal social communication skills of preschool children with an ASD provide consistent reports of impaired dyadic behaviours, which are considered central to later emerging difficulties in triadic engagement (Clifford & Dissanayake, 2008; Wetherby, Watt, Morgan, & Shumway, 2007). It is noteworthy that the abovementioned research consistently reports dyadic impairment among children with an ASD, which is reflected in their failure to establish eye contact in response to an adult's attention bid, or to initiate a shared experience with others. Collectively, these studies reveal that a lack of sensitivity to dyadic interactions established through direct eye gaze may lead to the widely reported delays in joint attention development among children with autism.

#### *Consequences of Dyadic and Joint Attention Impairment to Social Competence*

Studies of children with autism provide evidence for the developmental continuity between joint attention in infancy with later social competence (Mundy & Acra, 2006). For instance, joint attention is one of the most powerful predictors of language development in autism (Charman et al., 2003). Current research supports predictive associations between skills used in responding to (Thurm, Lord, Lee, & Newschaffer, 2007) and initiating joint attention (Toth, Munson, Meltzoff, & Dawson, 2006) with later receptive and expressive language skills. At the same time, spontaneous bids for joint attention provide infants with an opportunity to develop an understanding of their own and other people's minds (Mundy & Burnette, 2005). Indeed, the theory of mind (ToM) hypothesis, which

is widely cited in the literature, attributes social deficits in ASD to difficulties in ascribing mental states to oneself and others (Baron-Cohen, 2001). Although several recent studies have documented developmental gains among children with an ASD on a range of tasks tapping social meaning (e.g., Peterson, Wellman, & Liu, 2005; Steele, Joseph, Tager-Flusberg, 2003), individuals with an ASD frequently show specific impairments among ToM skills that are essential for regulating one's behaviour appropriately during social situations (Beaumont & Newcombe, 2006; Golan, Baron-Cohen, Hill, Golan, 2006; Steele et al., 2003). Furthermore, there is considerable evidence to suggest that children with an ASD mediate their successful performance on ToM tasks by relying on language and noncognitive processes, which may reflect a fundamental lack of social insight (Tager-Flusberg, 2007; Ruffman Garnham, & Rideout, 2001). Together, the research reviewed above indicates that difficulties in joint attention contribute to atypical social communicative development.

There are other, earlier-occurring factors contributing to the relationship between delays in joint attention and subsequent social cognitive development in autism. For example, Schertz and Odom (2007) argue that attention to faces, which is absent among young children with an ASD, is a developmental precursor to initiating joint attention because it allows children to relate to their social partner on an area of mutual interest, in part providing the foundation for language learning. Even among older individuals with high functioning autism, conversational difficulties are reflected in gaze management problems that can be construed to relate to the social disinterest in faces among infants with an ASD

(Paul, Orlovski, Marcinko, & Volkmar, 2009). Indeed, fundamental deficits in social orienting are indirectly related to language impairments in autism by reducing the number of opportunities for joint attention engagement (Bono, Daley, & Sigman, 2004; Dawson et al., 2004). In a related vein, Campbell et al. (2006) propose that a child's ability to make mental state judgments (i.e., ToM) develops from flexible attention switching between the face of their social partner and where or what the person is looking at to establish an area of mutual attention. In fact, the first characteristic in typical development related to the emergence of joint attention is the alteration of eye gaze between an object and a social partner during communicative exchanges (Bruinsma et al., 2004). Throughout development then, the failure to respond to social stimuli deprives individuals with an ASD of the nonliteral aspects of social situations and has lasting implications for their social communicative competence.

#### *Implications for Intervention*

Improvement in social engagement is considered one of the most critical treatment outcomes in ASD, which is characterized by life-long difficulty in reciprocal social interaction and communication (Rogers, 2000). A wide range of psychological, educational, and physical interventions are available for the treatment of autism. Only recently have researchers emphasized joint attention training for children with autism (Kasari, Freeman, & Paparella, 2001). These types of intervention programs reinforce joint attention skills so children learn to interpret adult communicative intentions, which are crucial for social communication development. Frequently, this type of social interactive training

occurs within the context of a child's everyday life and organizes the environment in a manner that increases both a child's interest in materials or activities, as well as his/her motivation to use social and communication behaviours (Hwang & Hughes, 2000). In doing so, children and their social partners learn how to coordinate episodes of mutual attention or interest with objects in their proximal surroundings.

Despite the importance of joint attention to later social development, there are only a few studies in the current literature examining intervention programs exclusively focused on joint attention skill training among children with an ASD (Kasari, Freeman, & Paparella, 2006). For example, Whalen and Schreibman (2003) presented the first study to systematically train joint attention behaviours among preschool children with an ASD using a single-subject multiple baseline design. Although they observed increases at post-treatment in joint attention behaviours, the improvements were limited at follow-up and not well generalized to other settings. More recent and well-designed randomized control trials (RCT) have extended Whalen and Schreibman's work. A recent RCT by Kasari et al. (2006) demonstrated improvements in both responding to and initiating joint attention following a brief, tailored program specifically targeting these behaviours, in comparison to children who participated in a symbolic play intervention and to children receiving neither program. Randomized control data of a psychosocial intervention, which focused on effective communication between parents and their children through joint attention exchanges, also yielded improvements in social engagement, reciprocity, communication, and language



skills among verbal and nonverbal children with an ASD (Aldred, Green, & Adams, 2004). Finally, increases in language skills were reported in a randomized trial of a parent-training program, which emphasized joint attention skills and routines (Drew et al., 2002). Collectively, the foregoing studies are supportive of research targeting early autism-specific deficits in joint attention to improve children's social and communication skills.

Given the influence of dyadic engagement in the development of joint attention, it is also important to understand the developmental factors underlying increases in joint attention behaviours. This may be especially imperative given the recent initiative among clinicians and researchers to improve early identification and intervention among toddlers with an ASD (Yirmiya & Ozonoff, 2007). In line with this idea, Schertz and Odom (2007) observed that toddlers successfully engaged in joint attention following a parent-mediated intervention emphasizing developmental precursors to joint attention, using a single subject multiple baseline design. Although not all the toddlers achieved this outcome, every child demonstrated improvement in attending to the faces of their social partners and turn-taking, which were hypothesized precursors to initiating joint attention. Moreover, dyadic engagement, which was reflected in an ability to focus on faces, represented a relevant developmental milestone among toddlers with an ASD who demonstrated joint attention. Although their results are limited by their small sample size, this study provides promising data regarding the use of developmental foundations of joint attention as a medium for intervention (Schertz & Odom, 2007). Thus, newly developed interventions for infants and

toddlers with ASD are incorporating developmental-based approaches to target parent-child interactions (see Dawson, 2008 for a review of *The Early Start Denver Model*; Smith, Rogers, & Dawson, 2008).

Finally, the studies reviewed above also highlight the importance of parent-child relationships as a priority in the treatment process. Recent research suggests that there are particular qualities of an adult's social behaviour that can increase the likelihood of children's social engagement. For example, Siller and Sigman (2002) observed that caregivers who synchronized their behaviour to their child's ongoing activity had children with superior joint attention and language development over a period of 1, 10, and 16 years. Similarly, Wimpory, Hobson and Nash (2007) found that adult actions, which were in tune with and encouraged a child's activity, fostered joint engagement between young children with an ASD and their parents. Thus, when parents tailor their communicative attempts to their child's interests, children with an ASD learn that naturally occurring communication is a rewarding and motivating experience (Siller & Sigman, 2002).

### *The Present Study*

Dyadic interactions that facilitate direct eye contact typically support the acquisition of joint attention skills and referential communication. Given that impairments in joint attention are typical of autism, it is vital to understand the nature of these difficulties and their amenability to change. No study to date has examined the relationship between gaze perception and intervention. As a result, the present paper reports on a pilot investigation of the newly developed *Eye Gaze*

*Preference Task*, which examines preferential attention to gaze directions, as an exploratory measure of treatment effectiveness among children with an ASD following a parent-mediated social communication intervention. Our aim was two-fold: (1) to examine if any collateral changes occur in gaze perception following a parent-training program targeting joint engagement and joint attention, and (2) to determine whether the Eye Gaze Preference Task can be used as an outcome measure of treatment effectiveness.

The current project was a supplemental component of an ongoing RCT of *More than Words-The Hanen Program*® (MTW; Sussman, 1999). The MTW program teaches parents how to use natural opportunities in their child's everyday life to facilitate dyadic social engagement and joint attention. Through practical training, the program aims to increase parents' skills in facilitating reciprocal social interactions with their children in a manner that adheres to and continues their child's interest or activity. As a result, children are socially engaged with their parents in a manner that fosters the dyadic coordination of shared attention. As part of the RCT, children recently diagnosed with an ASD between 2- to 4-years of age were randomly assigned to either a treatment group, such that their parents participated in the training immediately, or to a control group where parents were encouraged to contact local community services.

It was expected that children whose parents were participating in the training program would demonstrate increases in their joint attention skills. Given that responding to joint attention is a hypothesized precursor for spontaneous joint attention initiations (Schertz & Odom, 2007; Whalen & Schreibman, 2003), it was

predicted that joint attention responding would increase significantly more than the initiation of joint attention among children in the treatment group. Moreover, it was hypothesized that changes in joint attention would be reflected at a basic attentional level, such as in children's dyadic social orienting skills. As a result, it was expected that children from the treatment group would demonstrate longer fixation times and more orienting responses to faces displaying mutual gaze during the Eye Gaze Preference Task. Thus, the project was an exploratory study to determine whether the Eye Gaze Preference Task can detect changes in children's perception of different gaze directions following their parents' participation in the MTW program.

## Method

### *Participants*

All of the participants were recruited from an existing RCT of MTW for English speaking parents of children with an ASD at the Montreal Children's Hospital. The final group of children recruited for the RCT comprised the current sample and were the same children with an ASD who participated in the previous study (Manuscript 1).

The current sample consisted of fourteen children with an ASD ranging in age between 25- and 44-months (mean CA = 34.07 months,  $SD = 6.16$  months) who were randomly assigned to either a parent training (PT;  $n = 7$ ) or control group (CT;  $n = 7$ ). All children were recruited after they were seen for diagnostic purposes at the Autism Spectrum Disorder Clinic at the Montreal Children's Hospital. All diagnoses were made by experienced clinicians based on

observation and parental report from the Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, DiLavore, & Risi, 1999) and the Autism Diagnostic Interview-Revised (ADI-R; Lord, Rutter, & LeCouteur, 1994). The final sample was comprised mainly of children diagnosed with Autistic Disorder ( $n = 12$ ) as well as Pervasive Developmental Disorder not otherwise specified (PDD NOS;  $n = 2$ ). Both groups were fairly similar in their ethnic distribution such that the majority of families participating in the study were Caucasian (71.43%). All families spoke English in the home, except for one family in the control group who reported speaking only Mandarin. Several families in both groups spoke more than one language in the home (PTG: 71.4%; CG: 57.1%), however English was always one of them. Most children in the study attended daycare (85.7%) and approximately half the sample was enrolled in some form of intensive behavioural intervention (IBI). Please see Table 8 for participant characteristics.

*Randomization.* Complete details of the methodological design used in the RCT of MTW can be found elsewhere (Tidmarsh et al., manuscript in prep.). However, a brief overview of the randomization procedures will be reviewed here. Children were assigned to either the parent training or no treatment group based on a matched-pair, random assignment procedure. Following their initial intake assessments, children were matched on age, gender, and expressive language level, which was from the ADOS (i.e., overall level of non-echoed language). Subsequently, one member of each pair was randomly assigned to either the experimental group, who received the parent training immediately, or to the control group, who received the same treatment after a twelve-week period.

Control families were also encouraged to contact community services in the interim. For the purposes of the present study, the researchers were blind to the treatment status of each family.

### *Measures*

All children were administered the *Mullen Scales of Early Learning* (MSEL; Mullen, 1995) to determine level of developmental functioning, the *Vineland Adaptive Behaviour Scales* (VABS-II; Sparrow, Balla, & Dominick, 1984) to assess social and communication skills, and the Eye Gaze Preference Task to examine children's perception of different gaze directions. Please see Manuscript 1 for detailed descriptions of the abovementioned measures. Data from the clinical group who participated in the previous study (Manuscript 1) provided the pre-intervention data across these measures for the current project. Data collected at that time preceded families' participation in the parent-training program. As part of the ongoing RCT, children were also administered a measure of joint attention behaviour described below.

*Joint attention.* Joint attention skills were assessed using the *Early Social Communication Scale* (ESCS; Mundy, Hogan, & Doehring, 1996). The ESCS is a videotaped semi-structured observational tool designed to measure the development of nonverbal communication skills. The experimenter and child are seated facing each other across a table for a series of activities involving sets of toys (e.g., wind-up and hand-operated mechanical toys, ball, car, glasses, book, hat and comb) that are in view but out of the child's reach. To elicit joint attention and related behaviours, the experimenter administers five categories of tasks,

which include turn-taking activities, object spectacle (e.g., hand-held toy that makes noise), response to invitation, response to social interaction (i.e., singing a song with a tickle), pointing tasks, and following a command. Videotaped observations of the experimenter-child interactions are coded to provide scores for joint attention, behavioural requests, and social interaction behaviours. The variables of interest for the current project included frequency of joint attention initiations (coordinated looking, pointing, and showing) and responses (responding to the experimenter's points and gaze). The ESCS was coded by three separate raters blind to group assignment who achieved reliability scores over 80%.

*Intervention.* The More than Words® parent-training program (Sussman, 1999) was developed by the Hanen Centre in Toronto, Ontario, Canada for families with children with an ASD under 6-years of age. It is a twelve-week parent-oriented program to promote communication and social skills among children with an ASD. The format of the course required parents to attend 3-hour group sessions at the hospital led by a speech pathologist 8 times during the 12 weeks of the program. Parents were provided with a manual that compliments the group instruction from the training sessions. The speech pathologist also made three home visits for individual discussion and feedback.

The program's objective is for parents to develop the requisite knowledge and skills to help their children interact and communicate using naturally occurring opportunities throughout the day. The course content initially encourages parents to observe what motivates their child to communicate, with

particular attention to factors that influence their child's style of communicating, how and why their child communicates, as well as their child's understanding of communication. These observations help parents identify realistic communication goals for their child and how to evaluate and refine their expectations depending on the nature of their child's communication skills. Throughout the program, parents learn how to build successful communication with their child through a variety of techniques that facilitate their child's joint engagement and shared attention to activities. To do so, parents are encouraged to follow their child's lead and interest in activities, use visual supports to aid their child's understanding, arrange the environment to engage the child, use structured routines (e.g., songs with actions and physical games) and provide reinforcement that responds directly to what the child is trying to communicate. Parents then learn how to integrate and apply the strategies during their everyday routines (e.g., mealtime and child-care tasks) and activities (e.g., books, music, and toys). As a result, parents structure the environment in a manner that motivates their child to communicate with naturally occurring opportunities for joint attention. Previous work by McConachie, Randle, Hammal, and Le Couteur (2005) indicated that the MTW program provides parents with a repertoire of positive communication strategies and increases children's communication skills.

### *Procedure*

The current project was conducted with approval from the McGill University Ethics Committee (see Appendix A). Families were recruited and consent was reviewed for the current project as part of families' participation in



the RCT at the Montreal Children's Hospital. For purposes of the current project, pre-intervention data were collected during two separate visits to the Montreal Children's Hospital before the intervention training began. Post-treatment data were collected during one visit within 2 weeks after the 12-week training was completed. The control group received the same course of treatment after the post-treatment data were collected.

## Results

Data were analyzed using the Statistical Package for the Social Sciences (SPSSv.12.0). Descriptive statistics (i.e., mean, standard deviation) were computed across all measures. Parametric inferential statistics (i.e., ANOVA, MANOVA) were used to examine pre-treatment differences among group characteristics and whether significant changes were observed post-treatment across performance on the Eye Gaze Preference Task and in joint attention skills. Finally, a series of bivariate correlations were used to explore the relationship between joint attention and performance on the Eye Gaze Preference Task.

### *Initial Group Comparisons*

Separate analyses of variance (ANOVA) were computed to examine whether there were any significant pre-treatment differences in developmental functioning and social competence across participant groups. Developmental functioning was defined in terms of nonverbal (NVDQ) and verbal (VDQ) developmental quotients derived from the MSEL. NVDQ and verbal VDQ were calculated according to individual mental age scores derived from the MSEL (e.g.,  $NVDQ = (\text{nonverbal MA/CA}) \times 100$ ). Please see Manuscript 1 for a

discussion on the use of developmental quotients. Indices of social competence were defined by level of social adjustment (SOC) and communicative ability (COM; i.e., the former operationalized as the standard score on the socialization domain and the latter on the communication domain of the VABS-II). At the pre-intervention assessment, there were no significant differences in either area of functioning among children whose parents received the training and those who did not. Group means and standard deviation scores for these analyses are presented in Table 9.

#### *Changes in Performance on the Eye Gaze Preference Task*

To establish whether children's perception of gaze direction was influenced by the parent training program, children's performance on the Eye Gaze Preference Task was examined according to when children were presented with two faces simultaneously (i.e., 2-face condition) or when they were presented with one face (1-face condition). As a result, two repeated measures MANOVAs were computed with group (PT vs. CT) as the between-subject variable and time (pre- vs. post-intervention), as well as gaze (2-face condition: direct vs. averted; 1-face condition: direct vs. averted vs. closed), as the within-subject variables. Dependent variables associated with the pre and post-measures were the same as those described in Manuscript 1. To review, performance variables were defined according to gaze direction. In the 2-face condition, these included the mean length of the first fixation, the number of orienting responses, and the percentage of time spent fixating on faces. The mean length of the first fixation and the percentage of time spent fixating on faces were also used to

describe performance in the 1-face condition, whereas the total number of orienting responses was not included as a dependent variable as there was no attention shifting component during this portion of the task. Finally, preliminary tests of assumptions associated with repeated measures design, which were described in Manuscript 1 for the Eye Gaze Preference Task, were satisfied by the current analyses.

Following the intervention, very few significant differences were observed in children's performance of the Eye Gaze Preference Task. During the 2-face condition, there were no significant changes in performance related to group membership or gaze across time. Similarly, in the 1-face condition, there were no significant differences in children's viewing preferences for a face with a specific gaze direction related to group assignment. Although there was a significant univariate main effect of group related to the mean length of the first fixation ( $F(1,12) = 4.74, p < .05$ ) during the 1-face condition, this finding was not observed at the multivariate level. Furthermore, there was no significant interaction between group and time, which suggests that the groups differed in terms of their mean first fixations irrespective of whether children's parents received the training program or not.

In line with this idea, it is possible that the group separation was because participants' mean first fixations were largely discrepant at the outset of the study (see Figure 8). Figure 8 also reveals that there was virtually no difference across time in the mean first fixations among the group of children from the control group ( $M = 190.48, SD = 2715.03$ ). In contrast, children whose parents received

the training program demonstrated a greater mean increase in their average first fixations, albeit not to a level of significance ( $M = 592.86$ ,  $SD = 4431.75$ ). A similar pattern emerged across the course of treatment among performance variables during the Eye Gaze Preference Task: 2-face condition. Although group differences did not reach statistical significance, children whose parents participated in the MTW program demonstrated greater post-treatment increases in their orienting responses (direct gaze:  $M = 8.43$ ,  $SD = 11.85$ ; averted gaze:  $M = 7.28$ ,  $SD = 10.73$ ) and the percentage of time fixating on faces (direct gaze:  $M = 9.04$ ,  $SD = 15.6$ ; averted gaze:  $M = 7.73$ ,  $SD = 8.88$ ). In contrast, children in the control group demonstrated comparable performance across the course of treatment with respect to their orienting responses (direct gaze:  $M = .43$ ,  $SD = 9.69$ ; averted gaze:  $M = -.43$ ,  $SD = 9.91$ ; see Figure 9) and percentage of time fixating on faces (direct gaze:  $M = -1.05$ ,  $SD = 10.88$ ; averted gaze:  $M = 1.64$ ,  $SD = 12.11$ ; see Figure 10). There were no observed post-treatment differences during the 1-face condition in the percentage of fixation time on faces across both participant groups.

#### *Change in Joint Attention Skills*

To examine whether any changes occurred in children's joint attention skills that were attributable to the parent-training program, children's performance on the ESCS was examined across groups. This was achieved by computing a repeated measures MANOVA with time (pre vs. post-intervention) as the within-subject variable and group (parent training vs. control group) as the between-subject variable. The dependent variables were indices of initiating joint attention

(IJA) and responding to joint attention (RJA) described in the previous section. With respect to the assumptions associated with repeated measures analysis, the current data set was distributed normally and did not violate the assumption of homogeneity of covariance matrices (i.e., Box's test was not significant). Finally, the assumption of sphericity was not required in this analysis because there were only two levels of the within-subject variable.

For the current multivariate analysis, the  $F$ -value associated with Wilks  $\Lambda$  was used to examine the relationships among the variables. While there was a significant multivariate main effect of group ( $F(2, 11) = 4.65, p < .05$ ), tests at the univariate level were non-significant, questioning the robustness of the multivariate effect. A discriminant function analysis was also computed to determine if the multivariate significance was accounted for by a linear combination of the dependent variables, which yielded non-significant results. The multivariate effect may then be reflecting a complex relationship between the dependent variables or may not be meaningful (Stevens, 2002).

There was also a marginally significant main effect of time at the multivariate level ( $F(2, 11) = 3.37, p < .08$ ), which univariate tests revealed was exclusively related to initiating joint attention ( $F(1, 12) = 6.0, p < .05$ ). Polynomial contrasts revealed a significant linear trend ( $p < .05$ ) in the number of initiations (see Figure 11). Thus, these findings suggest that there was a significant increase between the pre- ( $M = 7.7, SD = 6.77$ ) and post-intervention ( $M = 12.14, SD = 8.85$ ) assessment in the total frequency that children attempted to initiate episodes of joint attention, irrespective of group membership. Finally,

there was no significant interaction between group membership and time, indicating that there were no significant differences observed in joint attention skills that were attributable to the parent-training program. However, visual inspection of the post-treatment mean differences indicates that children whose parents participated in the parent training demonstrated greater increases in their initiation of ( $M = 5.57$ ,  $SD = 8.14$ ) and response to joint attention ( $M = 5.71\%$ ,  $SD = 8.14\%$ ) in comparison to children in the control group, albeit not to a level of significance (IJA:  $M = 3.28$ ,  $SD = 5.02$ ; RJA:  $M = -.20$ ,  $SD = 21.28$ ; see Figures 12 and 13, respectively).

#### *Relation between Joint Attention and Performance on the Eye Gaze Preference Task*

Results from Manuscript 1 revealed that measures of social competence were predictive of the percentage of time spent viewing faces among children with an ASD. In particular, results from Manuscript 1 during the 1-face condition indicated a strong relationship between increases in fixation times toward faces across different gaze directions and stronger communicative skills among children with an ASD. To explore the extent to which this association extended to measures of joint attention, bivariate correlations were computed between performance on the Eye Gaze Preference Task and joint attention skills. In order to compare results across experiments and due to the lack of change across time, performance on the computerized task from the initial assessment was used in the current analysis. Furthermore, because there were no significant changes among participants that were dependent on the treatment manipulation, the correlations were computed collapsed across group membership.

There were no significant correlations observed between pre- or post-treatment joint attention skills and performance on the Eye Gaze Preference Task. More specifically, the likelihood that children with an ASD oriented to and fixated on faces was not related to either the frequency with which a child attempted to direct or respond to an individual's attentional orientation.

### Discussion

This short-term randomized control study explored whether children's perception of specific gaze directions and joint attention development were influenced by the MTW parent-training program. As there were no statistically significant post-treatment group differences across measures of gaze perception and joint attention, our hypotheses were not well supported by the current findings. However, an interesting trend emerged across the course of treatment among children whose parents participated in the MTW program, which fell short of significance but was in the expected direction. Children whose parents received the training demonstrated greater increases in their orienting responses and in their fixation times on faces during the Eye Gaze Preference Task. A similar pattern emerged on the measure of joint attention such that children in the treatment group demonstrated greater increases in their initiation of and response to joint attention. Notably, the post-treatment performance was equivalent across both measures among children in the control group, with the exception of their initiation of joint attention. Thus, these findings indicate that children with an ASD whose parents participated in the MTW parent-training program showed emerging developmental gains in core autistic symptoms. As no study to date has

examined the relationship between gaze perception, joint attention, and intervention, the conclusions are tentative and the exploratory data warrants further replication to draw reliable conclusions.

The present findings are in accord with recent studies that report on intervention approaches targeting early autism-specific deficits (Aldred et al., 2004; Kasari et al., 2006; Schertz & Odom, 2007; Whalen & Schreibmen, 2003). Furthermore, the findings are consistent with the perspective that adult behaviours, which attend to and build on a child's ongoing activity, results in increases in children's social engagement (Wimpory et al., 2007) and developmental gains in joint attention (Siller & Sigman, 2002). Clearly the current findings require replication among a larger sample of children and with designs that include comparisons to alternative treatment approaches. If replicated, then collectively these studies will provide further evidence for the inclusion of developmental-based, dyadic approaches to social communication treatment for children with autism (Aldred et al., 2004).

The second aim of the current paper was to pilot the Eye Gaze Preference Task as an outcome measure of treatment effectiveness. While our findings were non-significant, our results suggest that our task requires further development as an exploratory measure of face processing among young children diagnosed with an ASD. Although slight, but non-significant improvements were observed in joint attention behaviours, these skills were not associated with performance on the Eye Gaze Preference Task. Improvements in joint attention are typically associated with an increased sensitivity for gaze direction (Clifford &



Dissanayake, 2008; Wetherby et al., 2007; Leekam & Ramsden, 2006; Dawson et al., 2004), and as a result, it is possible that our task is not sensitive enough to detect subtle changes in children's gaze perception that may occur alongside developmental changes in joint attention. The current findings may also be due to the use of static pictures of human faces rather than pictures of dynamic social scenes. Subsequently, future studies using stimuli that are more social in nature may be necessary to understand the relationship between gaze perception and joint attention development.

At the same time, our findings raise the possibility that the Eye Gaze Preference Task is more strongly related to children's preference for faces, which is consistent with findings from Manuscript 1. Indeed, inspection of post-treatment changes among the group of children whose parents received the intervention indicates that differences were not influenced by gaze direction but rather reflected the likelihood that children oriented to and fixated on faces. This also suggests that the MTW program may improve children's dyadic social orienting, however future research with direct measures of social and non-social stimuli are needed to directly test this hypothesis.

This finding also raises an important question concerning the trajectory of face processing skills and their amenability to treatment. Several people have argued that face processing abilities are a relevant avenue for intervention (e.g., Dawson et al., 2002; Dawson, Webb, McPartland, 2005; Sasson, 2006). Even certain forms of intensive behavioural intervention explicitly target eye contact through teacher directed, discrete-trial training. "Look at Me" programs attempt to

increase eye contact and attention to faces through classical conditioning: a therapist's face (a neutral stimulus) is deliberately paired with a reinforcer (preferred food or toy; Dawson et al., 2005). In typical development however, head pose and eye direction perception are one of the earliest abilities relevant to the development of gaze monitoring and other shared attention skills (Triesch, Teuscher, Deak, & Carlson, 2006). Furthermore, joint attention and the motivation to communicate are fundamentally intertwined in both autism and typical development (Salt et al., 2002). Kasari and colleagues (2001) accurately point out that joint attention is a spontaneous, internally motivated communication skill that may not be easily taught or maintained through a reinforcement-based, externally motivated approach. In fact, the same may be true for the developmental origins of joint attention as well, especially if the ultimate goal of increasing dyadic social skills is to coordinate attention to an area of mutual interest with a social partner. As a result, parent-mediated psychosocial oriented approaches, such as MTW, that promote social communicative behaviours through natural opportunities in children's everyday environments may lead to better social communication outcomes for children with an ASD.

Although the current project was completed as part of a well-designed randomized trial, our findings are limited by several factors. First, ASD is a heterogeneous developmental disorder with considerable individual variability in autistic symptom severity and response to treatment (Dawson, 2008; Rogers & Vismara, 2008). Our study used a small sample of children and a heterogeneous control group where individual differences among children within and across

groups may have influenced our observed, albeit non-significant, differences in outcome measures. Second, the current project did not include follow-up data over a longer time period, which may be necessary to document gains in the developmental areas of dyadic and triadic attention (Rogers & Vismara, 2008). Finally, treatment fidelity measures were not included to audit how well or how frequently parents incorporated the teaching strategies of MTW into their daily interactions with their children. This is especially important as children with an ASD may learn about the social significance of head turns and gaze direction based on repeated observations of gaze cues and target pairings in their environment (Leekam et al., 2000; Nation & Penny, 2008).

In summary, there is both a theoretical and an empirical basis for why interventions focusing on dyadic reciprocity skills that lead to joint attention development should be implemented for young children with autism (Kasari et al., 2006). Currently, parent-child relationships are a priority in the treatment process due to the younger ages at which children are being diagnosed. Recent best practice guidelines outlined by the National Research Council (2001) underscore the importance of fostering spontaneous functional communication skills among children with an ASD and advocate the use of naturalistic teaching approaches that are child-driven and intrinsically reinforced to encourage child motivation and generalization of skills (Rogers & Vismara, 2008). Thus, dyadic social engagement and joint attention training represents an essential component of early intervention for children with or at-risk for autism to develop their non-verbal and verbal communication skills.

Table 8

*Demographic Information by Group*

| Characteristic                                   | Parent Program<br>( <i>n</i> = 7) | Control<br>( <i>n</i> = 7) |
|--|-----------------------------------|----------------------------|
| Gender ratio (boy:girl)                          | 6:1                               | 6:1                        |
| Mean chronological age ( <i>SD</i> )             | 34.57 (6.05)                      | 33.57 (6.71)               |
| Diagnosis  |                                   |                            |
| Autistic Disorder, PDD-NOS                       | 7, 0                              | 5, 2                       |
| Ethnicity  |                                   |                            |
| Caucasian  | 4                                 | 6                          |
| African  | 1                                 | 0                          |
| Asian  | 1                                 | 0                          |
| Middle Eastern                                   | 0                                 | 1                          |
| Mixed background                                 | 1                                 | 0                          |
| Number of children attending daycare             |                                   |                            |
| Pre-intervention; mean hours/week ( <i>SD</i> )  | 4; 12.5 (14.74)                   | 5; 20.0 (18.95)            |
| Post-intervention; mean hours/week ( <i>SD</i> ) | 5; 16.67 (14.37)                  | 7; 18.21 (14.27)           |
| Number of children receiving 1:1 IBI             |                                   |                            |
| Pre-intervention; mean hours/week ( <i>SD</i> )  | 2; 3.14 (7.47)                    | 3; 3.14 (4.18)             |
| Post-intervention; mean hours/week ( <i>SD</i> ) | 2; 4.28 (7.87)                    | 5; 13.57 (14.35)           |

*Note:* IBI = intensive behavioural intervention.

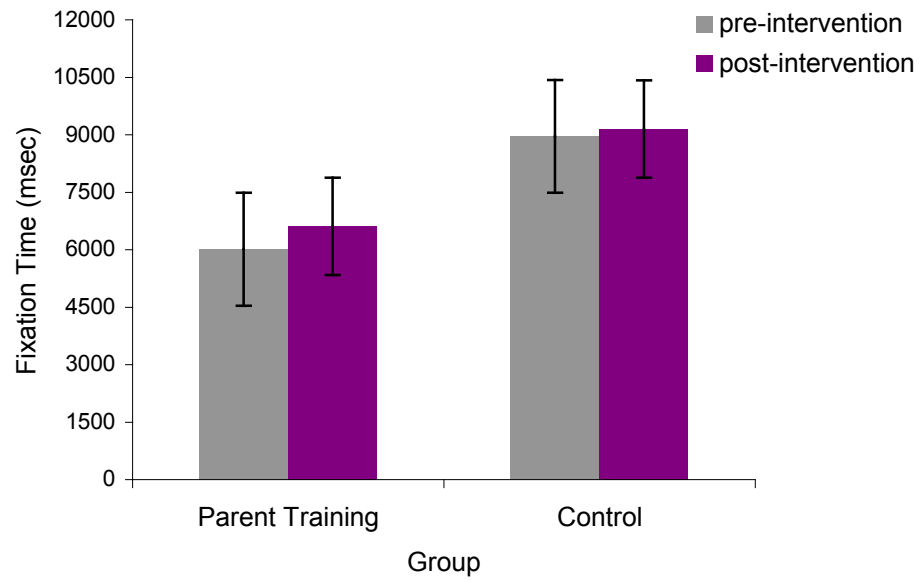
Table 9

*Initial Group Comparison in Developmental and Social Functioning*

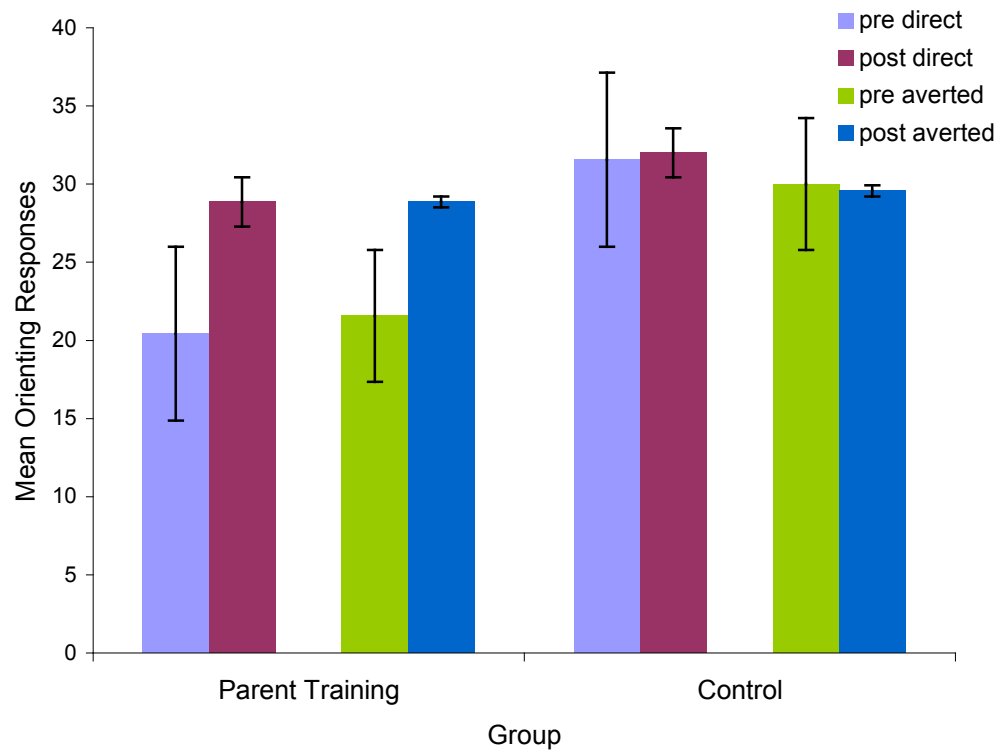
|                           | Parent Training | Control Group |
|---------------------------|-----------------|---------------|
| Developmental Functioning |                 |               |
| NVDQ Mean ( <i>SD</i> )   | 69.91 (16.99)   | 64.46 (15.65) |
| VDQ Mean ( <i>SD</i> )    | 56.11 (26.64)   | 52.97 (23.15) |
| Social Competence         |                 |               |
| SOC Mean ( <i>SD</i> )    | 75.0 (8.20)     | 78.14 (4.56)  |
| COM Mean ( <i>SD</i> )    | 75.0 (13.77)    | 80.14 (8.61)  |

*Note.* *NVDQ* = nonverbal developmental quotient; *VDQ* = verbal developmental quotient; *SOC* = social adjustment; *COM* = communicative ability.

*Figure 8.* Mean first fixations ( $\pm 1$  S.E.M) pre- and post-treatment according to group membership.



*Figure 9.* Post-treatment differences according to group membership among children's mean number of orienting responses to faces with either a direct or averted gaze during the Eye Gaze Preference Task: 2-face condition.



*Figure 10.* Post-treatment differences according to group membership in the percentage of time children fixated on faces with direct and averted gaze directions during the Eye Gaze Preference Task: 2-face condition.

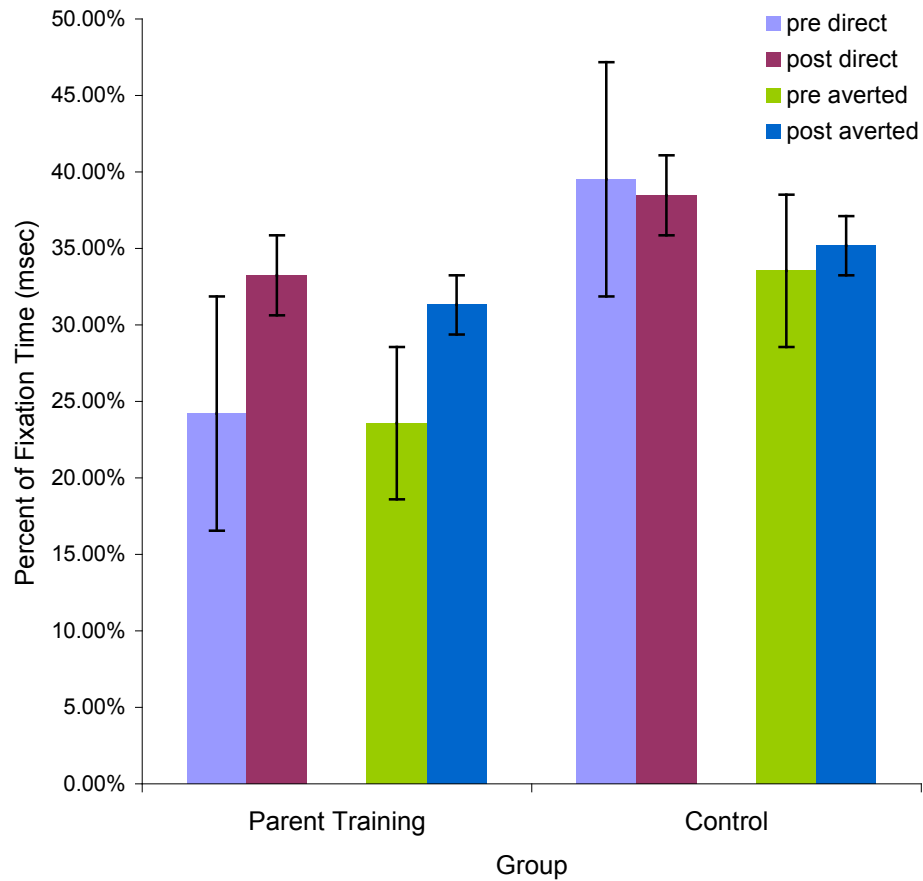




Figure 11. Increases in initiating joint attention ( $\pm 1$  S.E.M.) across treatment.

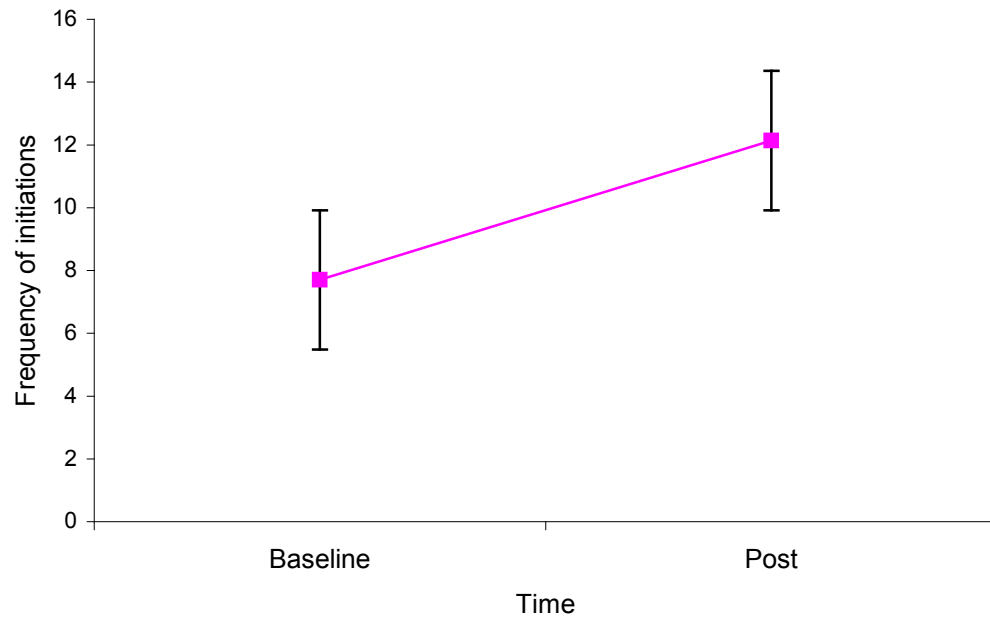
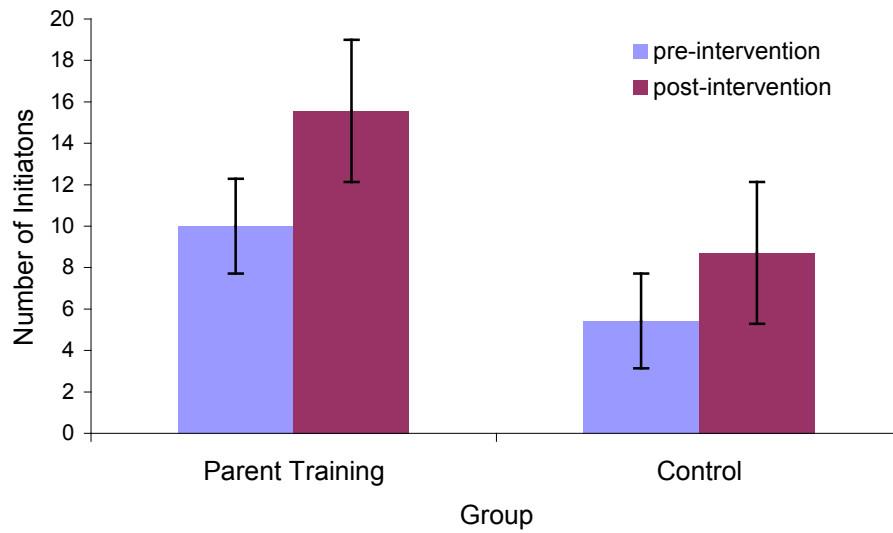
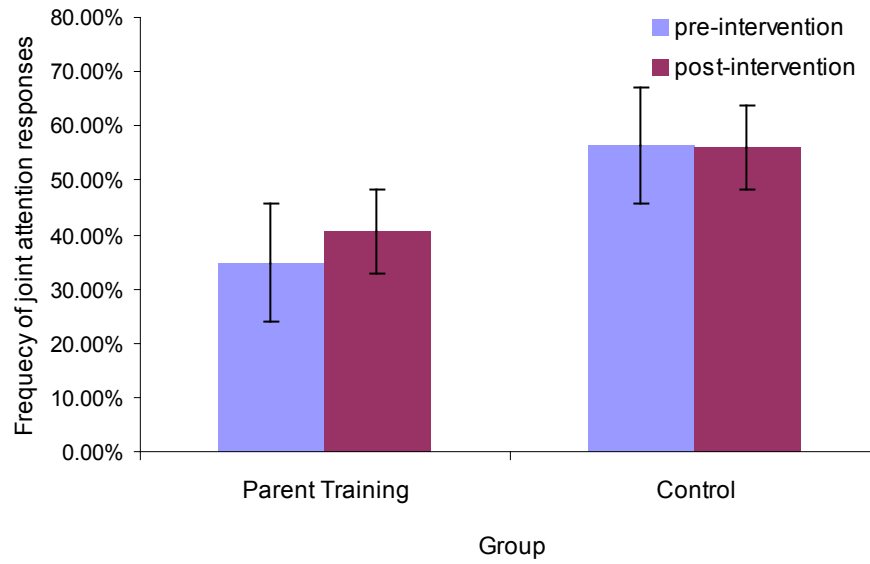


Figure 12. Non-significant post-treatment increases in initiating joint attention ( $\pm$  1 S.E.M.) according to group membership.



*Figure 13.* Non-significant post-treatment increases in responding to joint attention ( $\pm 1$  S.E.M.) according to group membership.



## GENERAL DISCUSSION

The aim of the present thesis was to examine the gaze perception skills of preschool children with an ASD within the context of their social communication skills using the newly developed Eye Gaze Preference Task. In the first manuscript, we established that young children with an ASD demonstrate shorter fixation times and fewer orienting responses to human faces in comparison to typically developing children matched on either chronological or mental age. Among participants with autism, children who presented with better-developed language skills also demonstrated longer fixation times to faces during the Eye Gaze Preference Task. In the second manuscript, we observed that inattention to faces, which is a core autistic symptom, may be malleable in early childhood and responsive to a social communication intervention targeting episodes of dyadic engagement and joint attention between children and their caregivers. Finally, the study also provided promising data for the utility of the Eye Gaze Preference Task as an outcome measure of treatment effectiveness to capture subtle changes in children's spontaneous viewing patterns for faces.

This thesis represents a unique contribution to the autism literature by extending our current knowledge of the relationships between face processing, social communication, and intervention among young children with an ASD. The findings have theoretical and applied implications as well as many avenues for future research, which will be addressed in the following sections.

### *Theoretical Implications and Future Research*

Humans may be socially predisposed to look, share, and interact with others at a dyadic level (Hobson & Meyer, 2005). For instance, typically developing newborns exhibit an early sensitivity for faces with direct gaze, which provides the social building blocks for a joint attention system that first emerges at 3- or 4-months of age. Consequently, several developmental theorists posit that there are critical periods in infancy where particular visual material is reliably present, which results in the maturing and organization of certain cortical structures (Johnson, 2005; Mundy & Burnette, 2005). Namely, the term experience-expectant development refers to a readiness of the brain to receive specific types of information that are reliably present in the environment (Dawson, Ashman, & Carver, 2000). As a result, there are a number of newborn biases and preferences in place that drive subsequent social brain and behaviour developments.

This has specific implications for developmental models of autism across several research domains. First, several hypotheses have been put forth to explain the aetiological mechanisms that contribute to face processing impairment in autism. For example, researchers have proposed that face processing impairments reflect reduced social interest or motivation in faces (Dawson et al., 2005; Mundy & Burnette, 2005; Elgar & Campbell, 2001), abnormalities in the magnocellular system that supports visuospatial skills needed for face processing (Elgar & Campbell, 2001; Plaisted & Davies, 2005), or problems in executive functioning (Hill, 2004). In typical development however, newborn biases in visual orienting cause faces to represent a consistent input to developing cortical areas (de Haan,

Humphreys, & Johnson, 2002). In particular, infants' face preference reflects early constraints of the visual system that biases newborns' visual orientation toward the eye region of faces (Turati et al., 2005). As a result, the ability to process information from eye gaze develops earlier than the processing of information from faces among typically developing infants (Taylor, Edmonds, McCarthy, & Allison, 2001). Thus, gaze detection skills emerging early in development have implications for cortical development supporting face processing skills, which are essential for social cognition (Farroni, Johnson, & Csibra, 2004).

It is conceivable that children with autism mature differently from the embryo-genetic level. In particular, subtle differences in prenatal cortical structure and activation patterns may lead to functional variations in brain systems contributing to typical human behaviour (Karmiloff-Smith, 1998). This hypothesis raises the possibility that infants affected by an ASD may not be predisposed to orient to the eye regions of their social partners, which typically mediates social learning opportunities between infants and their caregivers. Developmental processes may then give rise to even greater differences among socially mediated experiences that are critical for the typical trajectory of brain and behaviour developments related to gaze processing, joint attention and theory of mind. Although this hypothesis is purely speculative, future prospective research among high-risk samples has the potential to address these issues by examining the neural origins and developmental trajectories of children's face processing skills.

Second, if difficulties in face processing begin with dysfunctional eye gaze in infancy, then what are the implications to social neurodevelopment during the first years of life? Although there are a number of studies among older, more able individuals with an ASD where atypical activation patterns are observed among cortical regions that typically facilitate face processing (e.g., Dalton et al., 2005; Mosconi, Mack, McCarthy, & Pelphrey, 2005; Pelphrey, Morris, & McCarthy, 2005; Ristic et al., 2005; Senju, Tojo, Yaguchi, & Hasegawa, 2005), there are relatively few studies among young children (e.g., Grelotti et al., 2005; Grice et al., 2005). Therefore, future research that includes electrophysiological measures among a prospective study of infants at high-risk for autism can foster our understanding of the critical role of developmental change on brain and behaviour end-states, which are functionally interdependent and develop dynamically over time (Karmiloff-Smith, Brown, Grice, & Paterson, 2003).

Finally, given the importance of gaze in typical development, it is important to determine the underlying processing strategies young children with an ASD employ when they engage with faces. In particular, when infants with an ASD fixate on faces what specific facial features do they attend to? Although older individuals tend to fixate less on the eye regions of a face (Klin et al., 2002a; Pelphrey et al., 2002; Trepagnier et al., 2002), there is only one study documenting the spontaneous viewing patterns to facial stimuli among infants at high-risk for an ASD. The current project was not able to answer questions specially related to the development of gaze perception skills among preschool children with autism. As a result, prospective studies of high-risk infants, which

include eye-tracking measures can address the developmental trajectory of gaze detection skills in ASD. If eye gaze detection skills emerge before the detection of facial detail among typically developing infants (Taylor et al., 2001), then what is the developmental pattern of attention to facial features among infants with an ASD? This research domain may be particularly important to improve early detection and intervention efforts for young children with an ASD.

#### *Applied Implications and Future Research*

Currently, researchers are focused on identifying primary developmental mechanisms that give rise to later impairments characteristic of ASD. Although impairments in joint attention are a robust indicator of an ASD diagnosis (Ventola et al., 2007), the current diagnostic criteria for autism are not developmentally appropriate for young infants (Zwaigenbaum et al., 2007). Results from both manuscripts have practical applications to the early detection of children with an ASD. In particular, the findings lend empirical support for the assessment of children's dyadic reciprocity skills when evaluating young children for signs of autism (Bryson et al., 2007; Zwaigenbaum et al., 2005). The continued development of the Eye Gaze Preference Task as an objective, performance-based screening measure for the early detection of children at risk for ASD also represents a relevant avenue for future study. However, the reliability and validity of the Eye Gaze Preference Task as a diagnostic tool would need to be established empirically. The paradigm might also have additional diagnostic power to discriminate between young children with autism and those children who present with early autism-like characteristics but who have a distinct genetic origin for



their disorder, such as Fragile X syndrome.

If delays in joint attention arise because of difficulties in dyadic engagement, then future research is necessary to understand the nature of this impairment in autism. For example, potential research questions that can fine-tune our knowledge of the social orienting impairments in autism include: Are there subtle variations in fixation patterns to faces among high-risk siblings who acquire a diagnosis in comparison to those who are unaffected? If there is a relationship between fixation patterns and level of communicative functioning among children with autism (Manuscript 1), then is inattention to faces a result of children's language delay? Comparisons to children with developmental language disorders and/or language delays can address this question. And lastly, do variations in fixation patterns also exist between classes of stimuli that are more developmentally sensitive, such as pictures of children's faces or cartoon facial images? By documenting markers of impaired social attention, these studies offer promise of identifying early-occurring phenotypic risk factors for an ASD.

Early postnatal years represent a sensitive period with regard to the long-term implications of early intervention on brain and behaviour development for genetically based disorders, such as autism (Dawson et al., 2000). Results from the second manuscript contribute to the growing body of literature related to evidence-based treatments for children with an ASD. Future, well-designed studies are required to replicate our results among a larger sample of children, while also accounting for the variation in behavioural symptoms across the autism spectrum. Future work incorporating brain-based measures can also begin to

document whether early intervention results in more typical patterns of brain activation among young children with ASD (Dawson, 2008). Together, this research can provide fine-tuned guidance for intervention approaches developed for children with autism.

An important practical contribution of this thesis relates to teaching practices that intervention programs incorporate for young children with autism. It is well established that the development of reciprocal social and communication skills is delayed, impaired, or atypical among individuals with an ASD (McConnell, 2002). These developmental differences have cascading consequences for the maturity of social cognitive skills, which are required to respond appropriately during social situations and establish human relationships. The lasting implications of these difficulties are reflected in higher levels of anxiety and depression, as well as in problems sustaining relationships commonly reported among older individuals with autism (Howlin, 2000; Stewart, Bernard, Pearson, Hasan, & O'Brien, 2006).

To date, the majority of publicly funded specialized intervention programs for children with an ASD are grounded in an intensive, behavioural skill-based approach that uses didactic massed trial teaching to improve children's level of functioning. Currently however, there are theoretical and empirical reasons why educational services should focus on pivotal areas of learning for children with autism, which may include language, social engagement, and sharing attention with others (Rogers & Vismara, 2008). It is therefore crucial that educators and parents alike target children's social communication impairments by being

interactive social partners who provide successful and motivating communicative experiences.

Children's social and communication skills are fundamentally intertwined with their educational needs. Social communication learning goals need to be identified when obtaining appropriate educational services, such as in the design of Individualized Education Plans or intervention programs. Teaching strategies that develop functional communication and social skills, which are developmentally appropriate and easily generalized to other settings, need to be incorporated into children's everyday routines inside both classrooms and homes. These types of educational practices would undoubtedly serve to increase instructional efficiency to positively impact children's educational experiences. For school-based approaches, future research is required to provide practical guidance in determining how to appropriately tailor current instructional practices to the social and communicative learning goals of children with autism.

The present findings lead to tentative suggestions that early interventions, which foster children's understanding of the social significance of faces and gaze direction, are an essential component of treatment for children with an ASD. There is however some evidence to suggest that this may not be an appropriate teaching practice for children with autism. Two separate reports (i.e. a brain-imaging and a physiological study) provide complimentary empirical evidence suggesting that gaze fixations and direct eye contact produce heightened emotional responses among older, school age children with an ASD, who ranged in their levels of cognitive functioning (Kylliainen & Hietanen, 2006; Dalton et

al., 2005). In John Elder Robison's (2007) memoir of living with Asperger Syndrome, he provides invaluable insights into the mind of an individual living with an ASD. In his narrative, he explains the following to account for his difficulty with regulating his eye contact during social situations:

To this day, when I speak, I find visual input to be distracting. When I was younger, if I saw something interesting I might begin to watch it and stop speaking entirely. As a grown-up, I don't usually come to a complete stop, but I may still pause if something catches my eye. That's why I usually look somewhere neutral – at the ground or off into the distance – when I'm talking to someone. Because speaking while watching things has always been difficult for me, learning to drive a car and talk at the same time was a tough one, but I mastered it.

These observations raise as many questions as they answer for treatment designs for children with autism.

Thus, an alternative to approach to intervening with children with an ASD can be extrapolated from the existing, although limited, literature on the development of joint attention and theory of mind among congenitally blind children. Although joint attention relies heavily on visual information, it is believed to develop in children with visual impairment as they learn to use non-visual cues to decipher the spatial relation of objects and other's attentional focus (Bigelow, 2003). Developmental gains are also observed in the mentalistic understanding of children with congenital blindness as their conversational skills improve, which not only facilitates dialogue about the mental states of others but

also allows children to socially interact with their peers (Green, Pring, Swettenham, 2004). Interestingly, recent neuropsychological studies provide similar findings among autistic populations where individuals with or at-risk for autism rely to a greater extent on verbal means to acquire information during social exchanges (Merin et al., 2007; Spezio et al., 2007a, 2007b; Klin et al., 2002a, 2002b). If future research continues to document that infants with an ASD prefer to look at the mouth region of their social partner, then optimal development in autism may depend upon our ability to capitalize on children's learning styles and strengths when implementing specialized teaching practices for young children with an ASD.

To conclude, young children with autism are impaired in their basic dyadic reciprocity skills, which has lasting implications for their social and communication development. Even after a brief period of time, children's dyadic orienting responses can begin to show improvement following a social communication intervention targeting social engagement and joint attention. Interventions that increase children's motivation to socially engage with their environment are likely to contribute to dramatic changes in social cognitive development among children with autism. Thus, it is hoped that specialized intervention programs, which impact key areas of impairment in autism, will promote the optimal development of children and families affected by ASD.

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## APPENDIX A



McGill

**Faculty of Education – Ethics Review Board**  
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Tel: (514) 398-7039  
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**Faculty of Education – Review Ethics Board**  
**Certificate of Ethical Acceptability of Research Involving Humans**

**REB File #:** 694-0806

**Project Title :** *Are changes in eye-gaze detection attributable to treatment among children diagnosed with Autism Spectrum Disorder?*

**Applicant's Name:** Danielle Ostfield **Department:** ECP

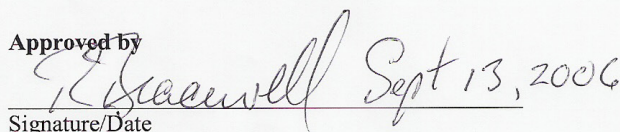
**Status:** PhD student **Supervisor's Name:** Kim Cornish

**Granting Agency and Title (if applicable):** n/a

**Type of Review:** Expedited ☒ Full ☐

This project was reviewed by: Derevensky/Shariff

**Approved by**

 Sept 13, 2006

Signature/Date

Robert Bracewell, Ph.D.

Chair, Education Ethics Review Board

**Approval Period:** Sept 13/06 to Sept 13/07

All research involving human subjects requires review on an annual basis. An Annual Report/Request for Renewal form should be submitted at least one month before the above expiry date. If a project has been completed or terminated for any reason before the expiry date, a Final Report form must be submitted. Should any modification or other unanticipated development occur before the next required review, the REB must be informed and any modification can't be initiated until approval is received. This project was reviewed and approved in accordance with the requirements of the McGill University Policy on the Ethical Conduct of Research Involving Human Subjects and with the Tri-Council Policy Statement on the Ethical Conduct for Research Involving Human Subjects.

9/13/06