Social Processing in Asperger's Disorder

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ABSTRACT

The ability to process social information is impaired in individuals with Asperger's Disorder (AsD). However, the nature of the impairment is not well characterized and the relationships among various aspects of social processing have not been investigated. The current study extends previous investigations of AsD by varying the complexity, modality, and type of social stimuli used to evaluate social processing. Twenty individuals participated in this study: 11 with a diagnosis of AsD and 9 age, education, and IQ-matched normal controls (NC). All participants demonstrated at least average intellectual ability. A battery of Social Processing tasks assessed the ability to perceive and interpret several types of socially relevant stimuli including faces, emotions (in faces and voices), nonverbal gestures, and complex social scenes. Results indicated a high degree of intercorrelation among the social processing tasks within the NC group, in contrast to a lack of association among task performances for the AsD group. More specifically, the ability to detect abnormalities in complex social scenes task was related to performance on "elementary" tasks (i.e., face recognition, emotion recognition) for the NC group, but to none of the elementary tasks for the AsD group. Group comparisons of individual tasks indicated impaired performance by the AsD group when presented with emotion in voices, emotion in faces, nonverbal gestures, and social scenes. In addition, the AsD group demonstrated impaired recall of the social scenes. Finally, the results indicated a unique pattern of impaired recognition of specific emotions in AsD. For the NC group, findings suggest that the ability to accurately perceive elementary social stimuli including faces and emotions is strongly associated with the ability to make

higher level judgments about social interactions. In contrast, the AsD results suggest that the social deficits in this disorder may be due to a lack of integration among the various perceptual and higher level abilities required to process complex social information. Furthermore, impaired processing of complex social stimuli appears to impact the ability to recall this information.

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Social Processing in Asperger's Disorder

In 1944, Hans Asperger described a syndrome which he called 'autistic psychopathy'. The word autistic was taken from Blueler's work on schizophrenia and according to Asperger this meant "a fundamental disturbance of contact" (Frith, 1991). The primary features of the syndrome included peculiarities of eye gaze, lack of facial and gestural expression, unnatural verbal language, impaired social relations, highly specific interests, stereotyped behaviors, and a sense of egocentricity accompanied by a lack of awareness of issues such as personal space and the emotions of others. His description of the syndrome emphasized the discrepancy between intact general intelligence and impaired social functioning. Consistent with current research, he noted that this syndrome appeared to have a genetic link and occurred primarily in males.

Today this syndrome is called Asperger's Disorder (AsD) and, although there have been some alterations to diagnostic criteria over the years, most of the features highlighted by Asperger are still recognized as symptoms of this disorder. At present, AsD is included as a distinct clinical category in the two commonly used psychiatric classification systems, the International Classification and Diagnostic Manual – 10^{th} revision (World Health Organization, 1993; World Health Organization, 1993) and the Diagnostic and Statistical Manual of Mental Disorders (American Psychological Association, 1994). In both systems, AsD is included in the subset of disorders labeled Pervasive Developmental Disorders (PDD) and the diagnostic criteria are virtually identical for both ICD-10 and DSM-IV. Impairment in social interaction is the defining feature and, according to DSM-IV criteria is defined by the presence of two of the following symptoms: marked impairment in the use of multiple nonverbal behaviors,

failure to develop peer relationships, lack of spontaneous seeking to share enjoyment, interests, or achievements with other people, and lack of social or emotional reciprocity. In addition, the second criterion is the presence of a pattern of restricted, repetitive, and stereotyped patterns of behavior, interests, and activities. Typically in AsD, this aspect of the disorder is manifest as an encompassing preoccupation with one or more stereotyped and restricted patterns of interest that is abnormal either in intensity or focus and/or apparently inflexible adherence to specific, nonfunctional routines or rituals.

In keeping with Asperger's original observations, DSM-IV requires that there is no clinically significant delay in cognitive development or in the development of age appropriate self-help skills, adaptive behavior (other than in social interaction), and curiosity about the environment in childhood. In addition, there must be no clinically significant general delay in language. Although language abilities such as vocabulary, syntax, and grammar must develop on time (i.e., single words by age two, communicative phrases by age three), it is widely recognized that pragmatic aspects of language are typically impaired in this disorder (Fine, Bartolucci, Ginsberg, & Szatmari, 1991; Fine, Bartolucci, Szatmari, & Ginsberg, 1994; Landa, 2000). Problems with para-linguistic qualities of language, such as timing of turn-taking and understanding irony and humor, are consistent with Asperger's observation of 'unnatural' language. However, poor pragmatics does not qualify as a language delay.

Individuals diagnosed with Asperger's Disorder demonstrate a life-long pattern of problems with socialization and this social impairment is the most debilitating feature of this disorder. Although children and adults with AsD often report an interest in social

interaction, difficulty with the nuances of interpersonal exchange often leads to rejection by peers. Adults with this disorder liken attempts to understand social interaction to comprehension of a foreign language. These individuals often try to learn and follow social "rules" and, at times, are able to manage specific aspects of social exchange according to a concrete formula. However, the flexibility that is critical to the flow of social interactions is almost always absent. Individuals with AsD are often aware of their limitations and, as a result, may avoid social situations for fear of feeling uncomfortable or rejected. As adults, these individuals are often viewed as "loners" and thought to be uninterested in social contact. While there is frequently a desire for social interaction and interpersonal relationships, a lack of success over the years often leads to an isolated lifestyle.

The distinctiveness of Asperger's Disorder lies in the fact that the disabling social deficits and related functional impairments occur in light of relatively skilled language and intact intellectual abilities. The intact abilities in AsD are in sharp contrast to the diffuse deficits present in autism, which is always defined by impairments in language development and involves intellectual levels in the mentally retarded range in about 75 percent of cases. Despite the clinical distinctions between these disorders, there is ongoing debate as to whether they are empirically distinct disorders or different functional levels of the same syndrome. In particular, the demarcation between high functioning autism (HFA), defined by intellectual functioning above the mentally retarded range (i.e., IQ >69), and AsD has been difficult to define.

The validity of AsD as a distinct diagnostic category has been a dominant research topic, primarily because of the overlap of symptoms and the genetic relationship

among AsD and autism. Many continue to view low functioning autism, HFA, and AsD as representing different levels of severity on an autistic continuum, despite empirical findings to suggest otherwise (Volkmar & Klin, 2000). Furthermore, Szatmari (2000a) recently highlighted the importance of factors such as natural history and response to treatment. He suggested that determining the clinical utility of Asperger's Disorder is at least as necessary as ascertaining its validity according to the traditional approach of focusing primarily on etiology. Some aspects of AsD and autism may fit with a continuum approach, while other features suggest clear distinctions. A dimensional view of autism and AsD, which is more accurate given the impairments in multiple functional domains, contradicts the continuum approach. Recent work suggests a positive change in thinking, as more studies are including pure AsD groups as opposed to mixed groups of HFA and AsD.

The present study investigated social-cognitive processing in a group of individuals diagnosed only with AsD. Regardless of one's stance about the validity of AsD, there are important reasons for studying this group in lieu of including a broader range of individuals with PDD. First, studies of AsD allow for improved understanding of social dysfunction in a group of individuals that present without confounds of intellectual impairment and language delay. Thus, narrowing the range of non-social dysfunction by including only those individuals with AsD offers a unique opportunity to investigate relatively isolated social impairment. This will likely be valuable, not only for improving knowledge specific to AsD, but to the understanding of social cognition in general. Second, methodological limitations often present in studies of low-functioning autism are not a concern when studying AsD. Designing tasks that represent ecologically

valid stimuli while taking into consideration language delay and low IQ is a challenging endeavor. Recent studies of AsD (Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997; Heavey, Phillips, Baron-Cohen, & Rutter, 2000; Klin, Jones, Schultz, Volkmar, & Cohen, 2002) have used stimuli that better approximate the demands of everyday social processing and as a result, unique perspectives of AsD are emerging.

Although methodology employed in studies of autism may not be particularly relevant for studies of AsD, the reported genetic links between autism and AsD (Folstein & Santangelo, 2000) and the overlap of some social features indicate that the abundance of current autism literature is theoretically useful for guiding current AsD research. In the present review, previous findings from relevant studies of autism will be included. For some types of social processing, there is little known about AsD and therefore the autism literature is the primary source of available information. It is important to keep in mind, however, that the similarities and differences between these two disorders are yet to be clarified. Therefore, while the autism literature offers guidance for AsD methodology and theoretical development, similar results are not necessarily expected in AsD.

From Asperger to the present

Despite describing the syndrome in 1944, Asperger's work was published in German and was subsequently known primarily in German and Dutch speaking countries. Only a few papers which discussed the syndrome described by Asperger were published in English between 1944 and 1980. In 1981, Wing introduced Asperger's syndrome to the English speaking world, sparking widespread research and clinical interest in this disorder. Since Wing's summary of Asperger's work, and particularly in the past decade,

the diagnosis of AsD has become increasingly common in psychiatric, medical, and educational settings and there have been many publications on the topic of AsD (Szatmari, 2000b). Although there has been increased debate regarding the validity of AsD as a distinct diagnostic category since the publication of ICD-10 (1993) and DSM-IV (1994), there also appears to be a strong acceptance of this disorder.

Wing (1981) not only introduced Asperger's initial work, she further described this disorder based on her own research with this population. She stated that the most obvious difficulty in Asperger's Disorder is impaired two-way social interaction and described this impairment in the following way:

> The problem arises from a lack of ability to understand and use the rules governing social behavior. These rules are unwritten and unstated, complex, constantly changing and affect speech, gesture, posture, movement, eye contact, choice of clothing, proximity to others, and many other aspects of behavior. The degree of skill in this area varies among normal people, but those with Asperger's syndrome are outside the normal range (p. 116).

Although difficulty understanding the rules and nuances of social exchange is the central feature in AsD, the nature of this observed deficit is not well understood. Despite a great deal of research interest, attempts to identify the underlying deficit(s) in AsD are currently hindered by a limited understanding of social cognition in general as well as a specific lack of knowledge about social deficits in AsD. At present, the range of abilities

that comprise social functioning is not yet defined. Although there are strong arguments for the existence of a social-cognitive module, the components and organization of this proposed module are still unclear. In addition, there is much to learn about the interplay between social cognition and cognitive abilities in other domains. Thus, a guiding theoretical framework for investigations of social cognition is not available at the present time. A second complication is the fact that many previous studies reporting impairment in various aspects of social functioning have involved mixed groups of autism and AsD. Furthermore, the few studies that have investigated the same ability (i.e., face recognition) in independent groups of 'pure' AsD have typically reported inconsistent findings. Such conflicting results may be due to variations in methodology, lack of ability to detect relative deficits due to small sample sizes, potential heterogeneity within AsD groups, or a combination of these variables. Thus, while there is consensus that social processing skills in individuals with AsD are outside of the normal range, clarification of the abnormal social abilities requires further research.

Despite limited knowledge regarding the social processing deficits in AsD, there are several interesting and plausible theories regarding the nature of the social impairment in this disorder. All current accounts of the underlying deficit(s) in AsD have emerged from the autism literature and are, therefore, not specific to AsD. These hypotheses can be divided into two camps: those that propose a non-social or *associative deficit* assumed to affect the individual's ability to process and produce social stimuli, as well as other types of non-social stimuli, versus accounts that suggest a core social deficit. Of the theories that propose a core social deficit a further division is represented in the literature: social-cognitive deficit (i.e., impaired social processing or reasoning)

versus motivational impairment (i.e., deficit in a basic social drive). Although current accounts of AsD and autism are not described in these terms (i.e., associative deficit vs. core social impairment), broadly categorizing and conceptualizing the theories in this manner is useful for understanding the similarities and differences among hypotheses.

Despite the plausibility of some current theories, the lack of consensus regarding both social and non-social deficits in AsD limits the possibility of moving forward. Although the current study did not directly address a particular theory or theories of AsD, the findings are relevant to the issue of associative vs. core social impairment. At a general level, an improved understanding of the social processing deficits in AsD is necessary in order to adequately address the issue of an underlying deficit. More specifically, this study systematically varied social stimuli in terms of complexity and modality type in order to begin to explore the relative patterns of deficits in AsD. An improved understanding of the social processing deficits in AsD, such as that offered by this study, will lead to the development of better methods for future investigations of the core deficit(s) in this group.

The next section includes a review of the most frequently discussed cognitive theories of AsD in the current literature. This is followed by a brief review of contemporary accounts of the neurobiological underpinnings of AsD. The final section is a summary of previous findings related to each type of social-cognitive stimuli selected for this study.

Core Social Impairment Theories

Social-Cognitive Impairment. At present, the Theory of Mind hypothesis is the only theory that argues for a core social-cognitive impairment in autism and AsD. This widely studied explanation proposes that the social deficits in autism and AsD are due to impaired Theory of Mind (TOM), a term used to describe one's ability to attribute mental states to others and often referred to as the ability to 'mindread' or 'mentalize'. Baron-Cohen and Ring (1994) described the Theory of Mind Mechanism (ToMM) as a modular system with two specific functions. The first purpose of the ToMM is to understand mental state representations including believe, think, know, and pretend and the second function is to use the representations of mental states in order to predict behavior. Thus, this system is thought to be both "explanatory and predictive". In everyday life, we are able to 'mindread' with relative ease and we rely on this social cognitive ability to guide our social interactions. According to the TOM deficit hypothesis, impairment in this mindreading system is the core deficit in autism and AsD.

Scheuffgen, Happe, Anderson, and Frith (2000) recently argued that TOM impairment may also be relevant in the uneven pattern of "intellectual" abilities (as measured by standardized measures of IQ) demonstrated in autism and AsD. The authors argued that many skills and abilities are learned through imitation and an understanding of agreed upon meaning and that mindreading ability plays a key role in these early learning processes. Furthermore, Frith (2001) recently reviewed cognitive and neuroanatomical data supporting a core deficit in mindreading in autism and concluded that there is a separable brain system responsible for development of TOM and that the brain abnormality in autism disrupts the intricate network underlying TOM.

Baron-Cohen and colleagues, as well as others, have used a wide variety of experimental tasks to offer support for a deficit in mindreading ability in autism (Roeyers, Buysse, Ponnet, & Pichal, 2001) and AsD (Baron-Cohen, Jolliffe et al., 1997; Baron-Cohen et al., 1999; Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001; Happe, Ehlers, Fletcher, & Frith, 1996; Jolliffe & Baron-Cohen, 1999a; Kaland et al., 2002). These tasks are categorized by complexity, which has been shown to correspond to developmental levels in normally developing children. There are various levels of TOM complexity, with more advanced levels requiring one to understand the mental states of various people (i.e., what does Joe think that Mary thinks about Sue?) or complex types of social communication, such as sarcasm and irony. At the other end of the complexity spectrum, 'first-order' TOM tasks can be solved by children at about age 4 and these involve being able to understand relatively simple aspects of what another person thinks or believes, requiring some minimal ability to take another's perspective. Individuals with autism consistently show deficits on TOM tasks at all difficulty levels, while individuals with AsD typically pass less complex TOM tasks (Bowler, 1992; Dahlgren & Trillingsgaard, 1996) but appear to have some difficulty with higher order tasks that are associated with later developmental stages in control groups (Baron-Cohen et al., 2001; Jolliffe & Baron-Cohen, 1999a).

While Theory of Mind is certainly a critical deficit in AsD (Frith, 2001), impairment in this area does not easily account for the broad range of social and functional problems, as well as other symptoms (i.e., narrow interests) present in Asperger's Disorder. In addition, reading others' minds is a relatively complex social-cognitive ability, which likely requires development of a more fundamental set of skills

first. At present, the TOM literature does not address this issue; there is minimal discussion of the developmental milestones that potentially underlie acquisition of TOM. Studies that show differences between social features of autistic and normally developing children at ages prior to the onset of TOM skills (Dawson, Meltzoff, Osterling, Rinaldi, & Brown, 1998; Osterling & Dawson, 1994) call into question the causative role of TOM in social development. Along these same lines, Klin (2000) argued that there is a lack of relationship between intact TOM abilities and social adaptation skills. That is, in higher functioning individuals, TOM abilities appear to be relatively intact despite the presence of impaired social skills, again adding doubt to the causative role of TOM impairments in the explanation of social deficits.

Klin (2000) recently addressed some additional limitations of TOM methodology. First, TOM tasks are strongly correlated with verbal skills (Bowler, 1992; Eisenmajer & Prior, 1991; Happe, 1995) and it appears that individuals with intact verbal abilities (i.e., individuals with AsD) typically pass lower order tests by relying on these skills. Furthermore, TOM tasks are explicit in nature and therefore require a different problem-solving format than the type needed in real-life situations. Finally, TOM methods typically involve a dichotomous approach (i.e., either TOM response or non-TOM response), rather than evaluating a continuum of functioning on these tasks. It is possible that relative levels of impairment on TOM tasks would be informative in the context of other intact and impaired abilities.

Although both clinical descriptions and research findings support the claim that individuals with AsD have poor mindreading abilities, current criticisms highlight the limitations of the TOM deficit hypothesis in explaining the range of symptoms in this

disorder or autism. Despite the fact that the TOM hypothesis has been at the forefront of social cognitive research in both autism and AsD, methodological weaknesses call into question the causative nature of this impairment. This does not, however, discredit the central importance of the concept of TOM in PDD. It may be worthwhile to re-focus research efforts in this area to investigations of skills needed to develop intact TOM and clarifications of earlier deficits in AsD and autism that may interfere with development of this ability. In addition, it will be important to move towards developing tasks that assess TOM by relying less on verbal skills and instead on presentation of stimuli that more closely represent everyday social demands.

Motivation Deficits. Several accounts of AsD and autism assert a core deficit in attending to social stimuli and, in essence, suggest a lack of the normal motivation or drive to preferentially attend to social aspects of the environment. Tantam (1992) hypothesized that a deficit in social attention is the fundamental deficit in Asperger's Disorder and autism. This was described as a deficit in the inherent tendency to direct gaze and attention towards social stimuli. Development of shared attention, the natural ability to orient to the direction of the gaze of others, requires intact social attention. When someone looks at a particular object, instinct tells us to follow the gaze of that person to also look at the object of interest. It is argued that other, more developmentally complex aspects of social communication (including Theory of Mind) are built on this commonly shared attentional structure. Without the basic foundation of social attention, children with AsD are unable to develop other critical social skills.

Interestingly, in support of Tantam's idea that eye gaze is of critical importance in the development of social abilities, several studies have indicated overlap in the social

impairments in autism and children with congenital blindness (Brown, Hobson, & Lee, 1997; Hobson, Lee, & Brown, 1999; Minter, Hobson, & Bishop, 1998). Symptoms sufficient to diagnose autism occur in a subgroup of congenitally blind children with a wide range of medical etiology. Furthermore, some autistic symptoms are frequently present in blind children that do not meet full diagnostic criteria for autism. Hobson, Lee and Brown (1999) compared an autistic group of blind children with an autistic group of sighted children and found similarities including elevated scores on the Childhood Autistic Rating Scale, poor peer interactions, and lack of diversity in play (i.e., stereotyped behavior). However, qualitative differences in the two groups were noted in the area of social-affective impairment; fewer blind children were reported to have difficulty with modulation of affect or lack of affect. Another study reported deficits in TOM in congenitally blind children, although to a lesser degree than the impairment in autism (Minter et al., 1998). An explanation for the presence of autistic features in congenitally blind children is not yet clear, but findings suggest that a lack of vision predisposes these individuals to difficulty in the development of complex social abilities. However, differences between these two groups, as well as the fact that only some children with congenital blindness meet criteria for autism, suggest that a core deficit in eye gaze does not account for the complete range of autistic symptomatology.

Dawson and colleagues hypothesize a similar deficit in basic social attention skills as potentially the earliest sign of autism. Retrospective studies (Dawson et al., 1998; Osterling & Dawson, 1994; Osterling, Dawson, & Munson, 2002) of first year birthday videotapes of children later diagnosed with autism have indicated impaired attention to social and language stimuli, as well as the presence of some autistic

behaviors such as self stimulation and covering of ears. Osterling and Dawson (1994) reported that the best predictor of subsequent diagnosis of autism was how often a child looked at others. Osterling et al. (2002) found that a combination of less frequent orienting to one's own name, looking at objects held by others, and looking at people best distinguished individuals with autism from typically developing children, as well as non-autistic children with mental retardation. Interestingly, "autistic-like" behaviors did not differentiate the non-autistic MR children and the autistic children, suggesting that some of these symptoms may be features of MR at this developmental stage, while the social attention features were unique to the autistic group. Dawson et al. (1998) also found that a group of children with autism, compared to Down's syndrome and normally developing children, demonstrated general impairment in orienting ability, with more severe impairment in responding to auditory social stimuli. In addition, shared attention (i.e., following other's gaze and declarative pointing) abilities were related to impaired social orienting, but not to non-social orienting. The authors propose that deficits in shared attention and other social skills may result, at least in part, from a fundamental impairment in attending to social stimuli.

While most previous research investigating social attention has investigated individuals with autism, some work suggests that eye gaze is also abnormal in AsD. Tantam, Holmes, and Cordess (1993) reported that individuals with AsD looked less at an interviewer, particularly when the interviewer was vocalizing. Normally, gaze toward someone increases when s/he is speaking. This study did not find the presence of gaze avoidance, but instead indicated eye gaze was not utilized in a normal fashion. Similarly, Willemsen-Swinkels, Buitelaar, Weijnen, and van Engeland (1998) reported that a group

of high- functioning autistic children gazed at parents as frequently as a normally developing group of children, but that the timing of eye gaze was abnormal relative to children without PDD. Although Dawson's work supports the presence of social attention impairments in autism as early as 8 months, there have been no investigations of individuals with AsD using similar methodology. Thus, there is little known about basic social attention at any stage of development in AsD.

Baron-Cohen and colleagues have reported a related deficit, described as impairment in the Language of the Eyes. Although discussed independently here, the authors (Baron-Cohen et al., 1999; Baron-Cohen et al., 2001; Baron-Cohen, Wheelwright, & Jolliffe, 1997) typically discuss this impairment as further support for a TOM explanation of autism and AsD. In an attempt to improve methodology for assessing advanced TOM in HFA and AsD, Baron-Cohen et al. (1997) developed a task that examines the ability of individuals to determine basic emotions and complex mental states when presented with only the eye region of a face. In normal controls, presentation of only the eye region resulted in the same level of performance as when the entire face was presented, while presentation of only the mouth region led to decreased performance. The AsD participants showed a general impairment in the identification of complex mental states, with the highest level of impairment for the eyes-alone condition. Results suggest that in normal individuals the eye region is critically important for extracting information from the face, while this does not appear to be the case in AsD. Consistent with the notion of decreased attention to the eye region, Klin et al. (2002) used eye-tracking methods to investigate social attention in adults with autism while viewing social

scenes. Results indicated less attention to the eyes in contrast to other areas including mouths, bodies, and objects.

Each of these accounts underscores the notion that social attention is an essential building block of social abilities and that the deficits in AsD and autism are linked to a lack of innate drive to attend to fundamental social stimuli (i.e., faces, eyes, voices). In typically developing individuals with intact vision this basic social drive is most frequently manifested as attention to the face and eye gaze of others. These accounts are consistent with a broad range of neurobiological findings and studies of evolutionary development that indicate a central role of the eye region in social communication (for a review, see Emery, 2000). Dawson and colleagues (Dawson et al., 1998; Dawson, Munson et al., 2002) also showed deficits in orienting to auditory social stimuli suggesting that the deficit in social orientation in autism is broader than impairment in eye gaze. Developmental work indicates that social orienting is present in infants within the first few months as demonstrated by an inherent attention to socially salient faces and soon after to relevant voices.

To further explore the role of social attention deficits in the development of various aspects of social functioning in AsD and autism, it will be important to investigate the earliest stages of development in these disorders and to follow children longitudinally. However, the inherent methodological problem for studies of early emerging social attention is the delay of diagnosis in autism and to a greater extent, in AsD. Perhaps targeting infants in families at-risk for autism or AsD or using retrospective methodology will offer more detailed information about early social deficits. The notion that failure in such a basic social ability may underlie subsequent

developmental abilities seems quite plausible and should be a focus of future research efforts.

Associative Deficit Theories

Other explanations of the social impairments in autism and AsD emphasize specific cognitive deficits in non-social areas, primarily attentional processes and executive functioning. These accounts are associative in that they do not suggest a core deficit in the social realm, but instead claim that a deficit in another cognitive domain disrupts the development of social abilities and/or impairs the processing of social stimuli. For the purpose of this review, only those accounts that hypothesize impairment in allocation of attentional resources will be summarized. Some of these accounts argue for an attentional bias while others suggest an inability to process multiple stimuli.

Weak Central Coherence. Frith (1989) introduced the term weak central coherence in an attempt to describe the core deficit in autism and to address both the social and non-social features of this disorder. Central coherence is defined as the ability to integrate information for higher-level meaning. According to Frith and Happe (1994), a bias towards processing details or local level information exists in autism and AsD, resulting in an inability to integrate multiple pieces of information into the overall meaning. This deficit is thought to impinge upon social and cognitive development as well as underlie the narrow interests and preoccupations in these disorders. In addition, cognitive strengths including superior performance on specific clinical and experimental tasks (i.e., Embedded Figures, Block Design) are claimed to result from this processing bias. Although there is substantial evidence supporting Frith's hypothesis of weak central coherence from studies of both linguistic (Jolliffe & Baron-Cohen, 1999b, 2000)

and visuo-spatial (Jolliffe & Baron-Cohen, 2001a, 2001b) processing in autism and AsD, some findings have been interpreted as evidence against the notion of impaired central coherence (O'Riordan & Plaisted, 2001a, 2001b). Although weak central coherence appears to capture some important aspects of cognitive processing in AsD and autism, as Jolliffe and Baron-Cohen (2001b) suggested, this theory currently suffers from over-extension and will require further refinement in order to overcome this limitation.

Abnormal Global-Local Processing. Similar to Frith's notion of weak central coherence, studies employing both clinical and experimental methods have indicated abnormalities in patterns of global-local processing. Initially, individuals with autism and AsD were reported to show a tendency to focus on smaller features (i.e. local components) rather than larger, global patterns, as measured by clinical tasks (i.e., Embedded Figures, Baron-Cohen & Hammer, 1997; Jolliffe & Baron-Cohen, 1997). Subsequently, methods similar to Navon's (1977) original investigations of global-local processing indicated normal global advantage and global interference effects in AsD and HFA (Rinehart, Bradshaw, Simon, Brereton, & Tonge, 2000; Rodgers, 2000); that is, response times were faster for identifying the global features as opposed to the local features of targets and when asked to identify local features, subjects were slower when the global and local features were incongruent. However, these studies also demonstrated that incongruent local information disrupted the processing of global stimuli in this group (i.e., slower global response times when incongruent local features were present), whereas in healthy control subjects, local features do not interfere with global processing because there is a relative preference to process global features. This finding in AsD/HFA suggests a selective deficit in the hierarchization of global and local features

(i.e., a lack of global precedence), characterized by a failure to inhibit local details, which then disrupts global processing. Mottron and Belleville (1993) hypothesized that this may be one of the primary underlying deficits in individuals with PDD and that this deficit crosses domains.

It is easy to imagine how a lack of central coherence or atypical global–local processing may disrupt social functioning. Many important, but subtle details must be processed during a typical social interaction. Attending to any one of the details, while failing to grasp the 'big picture', could lead to misinterpretation of the situation. Early in development, it is necessary to learn the relationships between local and global aspects of social stimuli and to determine how such information is best prioritized. It may be that abnormal processing in this attentional system disrupts processing of social stimuli from an early age, such that important social abilities are not learned appropriately.

Attention Deficits. Pierce, Glad, and Schreibam (1997) also argued for an attentional dysfunction hypothesis of autism. However, this account claims that the social impairment is due to an inability to attend to multiple cues. Findings indicated that autistic children performed within normal limits when only one social cue was present, but performance declined when more than one cue was present. Given the complexity of social environments, the authors propose that deficits in social processing and interaction are due to an inability to attend to multiple cues. Interestingly, the results of this study showed that individuals with low functioning autism were able to correctly answer questions pertaining to the mental states of others (i.e., TOM questions) if attentional requirements were minimal.

In addition theories related to abnormal allocation of attention, some studies have suggested that broader attentional deficit may contribute to the social impairment in autism and AsD. In particular, Attention Deficit-Hyperactivity Disorder (ADHD) is a frequently co-occurring disorder in AsD (Klin & Volkmar, 1997). Although the relationship between AsD and ADHD is not yet clear, there is emerging evidence suggesting overlap in the social deficits in these two groups. A high percentage (65 – 80%) of parents of children with ADHD reported problems with social interaction and communication, consistent with features of AsD (Clark, Freehan, Tinline, & Vostanis, 1999). Recent studies (Cadesky, Mota, & Schachar, 2000; Rapport, Friedman, Tzelepis, & Van Voorhis, 2002; Singh et al., 1998) have also reported deficits in affect recognition in adults and children diagnosed with ADHD. Rapport et al. (2002) found deficits in emotion recognition in ADHD that appeared to be independent of attentional problems. While it is often assumed that the social difficulties accompanying ADHD are secondary to difficulty with impulsive behaviors and difficulty inhibiting inappropriate behavior, these recent findings suggests there may be more fundamental social deficits underlying these problems in ADHD. From a developmental perspective, it may be that individuals with broad attentional problems may have more difficulty directing their attention to the relevant aspects of social stimuli and therefore miss important pieces of information, such that the accumulation of important social knowledge is disrupted.

Although general attentional impairment may complicate the social development of AsD, there seem to be distinctions in the presentation of attention problems in AsD and ADHD (Klin & Volkmar, 1997). Difficulty with selective attention and internal distraction are often part of the syndrome associated with AsD while the primary

attentional problems in ADHD include external distractibility and difficulty focusing and sustaining attention. Furthermore, attention problems in AsD are reported most frequently in younger children, but to a lesser extent in adolescents and adults, suggesting that developmental level plays a role in attentional processes in this disorder. It is hoped that future studies will seek to clarify the role of general attentional deficits in social development in various clinical groups as well as to define in more detail the relationship between AsD and ADHD.

Neurobiological Models

In addition to cognitive theories, neuroanatomical models of autism and AsD have been a major topic of interest in the literature. Although structural imaging has not been successful in identifying homogenous brain abnormalities in either disorder, leading research groups (i.e., Klin and colleagues, Baron-Cohen and colleagues, Dawson and colleagues) have recently modified various tests of social cognition, TOM, central coherence, and social attention for the purposes of functional imaging and initial results are promising. Current models of neuroanatomical impairments in AsD and autism are based on a combination of cognitive findings, emerging functional imaging data, animal models (Bachevalier, 1994) a few studies of neuropathology (Bauman & Kemper, 1985; Casanova, Buxhoeveden, & Switala, 2002; Casanova, Buxhoeveden, Switala, & Roy, 2002) and knowledge about the function of specific brain regions in normal social processing. Although the components of a neuroanatomical model of autism and AsD differ slightly among authors (Adolphs, 1999; Baron-Cohen & Ring, 1994; Baron-Cohen et al., 1999; Brothers, 1996, 1997) the amygdala is consistently hypothesized to hold a central role. Regions of the prefrontal cortex, as well as the superior temporal sulcus, are

also considered to be important parts of social circuitry (Brothers, 1996; Dawson, Munson et al., 2002; Frith, 2001).

The emphasis on the amygdala in these models is based on extensive literature describing single cell recordings and lesion studies in humans and non-human primates. Damage to the amygdala in both humans and non-human primates leads to changes in social behavior and an apparent deficit in the ability to recognize fear or to exhibit fear in situations that would normally elicit a fear response (Calder, Lawrence, & Young, 2001). Decreased emotionality is reported to be a primary consequence of amygdala lesions in humans (Brothers, 1996). Lesion studies involving the amygdala and surrounding entorhinal and perirhinal cortex in juvenile monkeys produced autistic-like behavior including social isolation, lack of eye contact, poor body language, strong negative reactions to new situations, and motor stereotypies (Bachevalier, 1994). In addition, neuropathological (Bauman & Kemper, 1985) and neuroimaging (Howard et al., 2000) studies of autism have indicated some evidence for abnormal structural features of the amygdala.

A primary role of the amygdala is the signaling of emotional or social salience of stimuli to other regions of the brain (Adolphs, 1999). By indicating emotional valence, the amygdala plays an important role in establishing relationships between stimuli and rewards (Schultz, Romanski, & Tsatsanis, 2000). Klin (2000) reported that individuals with AsD have difficulty identifying the salient elements of socially laden stimuli. A similar pattern of performance was reported in a patient with damage to the amygdala (Heberlein et al., 1998) suggesting that this task relies, to some extent, on the amygdala or related circuitry. Tantam's (1992) theory of impaired social gaze also proposes

involvement of the amygdala and surrounding areas of the limbic system. Impairment in this system in AsD and autism is thought to disrupt the normal development of responding to faces as emotionally salient stimuli. As a result, these individuals do not develop the 'expertise' in face recognition that is typical in socially intact individuals. A recent fMRI study (Schultz, Gauthier et al., 2000) demonstrated different patterns of activation during face recognition in individuals with AsD as compared to normals, offering strong support for the notion of a lack of face expertise. Schultz and colleagues hypothesized that impaired function of the amygdala underlies the abnormal face processing in AsD.

Support for a central role of the amygdala in autism is relatively convincing, but the findings are less clear in AsD. The strength of the amygdala hypothesis in autism lies in the neuropathological findings and the similarities in autism compared with animal models and humans with lesions in this structure. However, application of these same animal and human models to AsD is somewhat problematic due to the differences in clinical presentation. In particular, individuals with AsD typically do not present with the primary features seen in autism and the non-human primates with amygdala lesions, namely social withdrawal and motor stereotypies. Individuals with AsD usually seek social contact, but their awkwardness in the social domain may lead to social isolation. Although narrow interests and preoccupations are important features of the clinical presentation, motor stereotypies of the type observed in non-human primates with amygdala lesions are reported infrequently in AsD. Thus, the relative role of this structure in AsD versus autism remains to be seen.

The prefrontal cortex is a second brain region of interest in autism and AsD. It is proposed that the medial temporal lobe (comprised of amygdala, hippocampus, and entorhinal cortex) and the ventromedial region of the prefrontal cortex comprise a circuit that is specific to social cognition (Brothers, 1990; LeDoux, 1994). Studies of frontal lobe (i.e., executive) function in AsD and autism have been mixed, but Dawson, Munson et al. (2002) correctly argued that most studies have utilized tasks that tap dorsolateral prefrontal functioning, which is not the proposed region of involvement. Dawson, Munson et al. reported a relationship between joint attention ability and ventromedial, but not dorsolateral, prefrontal tasks in a young group (3-4 year olds) of children diagnosed with autism or PDD-NOS. The authors suggest that ventromedial prefrontal cortex plays a role in the development of joint attention, which is one of the earliest impairments in social functioning in autism. In addition, preliminary functional imaging work suggests that the medial prefrontal cortex is of primary importance in TOM or 'mentalizing' ability (Frith, 2001), and appears to be part of a TOM network that also includes the superior temporal gyrus and amygdala. Although there is some variability with regard to the proposed region of prefrontal cortex involvement in AsD and autism, there seems to be consensus that prefrontal cortex is an important component of a brain circuit specific to social ability.

The Current Study

This review highlights the various plausible cognitive accounts of autism and AsD, as well as possible neuroanatomical correlates of social impairment. However, as discussed earlier, empirical results specific to AsD currently lag behind theoretical developments. Until recently, much of the work in AsD followed from studies of autism

and thus, similar methodology was employed. This has likely hindered progress in that many of these tasks were not designed for individuals with intact intellect and language abilities. Many studies have pointed to the compensatory mechanisms in individuals with AsD, arguing that intact performance on tasks intended to measure social abilities may not necessarily represent intact social processing.

The present study was undertaken in order to address some specific limitations of previous research and to begin to address questions that may lead to future explanations of the underlying deficit(s) in AsD. A primary goal of this study was to lay out the magnitude and breadth of social processing difficulties and to improve upon current knowledge of the unique social deficits in this disorder. By employing a battery of tasks that assessed a broad range of abilities, rather than focusing on one specific area of processing, it was possible to make several comparisons that have not been addressed by previous work. First, social stimuli representing varying levels of processing complexity were selected for the Social Processing battery. That is, some tasks required the participant to respond to only one type of stimuli, while others demanded more complex processing of multiple pieces of social information. If deficits are only present on tasks of increased complexity, this would generally support the notion of an associative impairment, such as an attentional deficit. In contrast, deficits on tasks that present stimuli central to social exchange but have fewer processing (e.g., attentional) demands, would be suggestive of a core social impairment. Given the compensatory abilities of individuals with AsD (i.e., intact intelligence, good verbal reasoning) impairment on a task that has minimal processing demands likely represents an important deficit area, fundamental to the social impairment.

The second issue addressed by this battery of Social Processing tasks was that of modality specific social processing. Nonverbal deficits are often emphasized in the literature and, according to current diagnostic criteria, are a primary problem for this population. Language skills are typically highlighted as an area of strength in AsD. In order to assess the possibility that modality of social stimuli may affect the processing and comprehension of the stimuli, this study included tasks that contained verbal, nonverbal, and mixed modality stimuli.

Furthermore, the current battery of social tasks allows for an investigation of the relationships among specific abilities as well as between complex and less complex tasks. In particular, this study addressed the following questions: Are the relationships among these social processing tasks normal or idiosyncratic within the AsD group? What can the pattern of relationships among task performance tell us about the pattern of social processing deficits and the organization of social cognitive skills in the AsD group? Knowledge about the relationships among tasks may also shed some light on the overarching issue of whether there is support for an underlying core social impairment or an associative deficit in AsD.

The tasks included in the Social Processing battery were selected based on previous AsD and autism literature, previous research investigating social cognition, clinical descriptions of AsD, and clinical experience with this population. Several novel tasks and social stimuli were designed for this study. Each task was included because it was believed to represent a type of stimuli that is important in everyday social functioning. The battery of Social Processing tasks is not considered to assess an exhaustive list of social processing abilities, but the tasks are thought to represent a

comprehensive set of core social stimuli. Following is a summary of the social stimuli included in the battery and an overview of each task. Previous research, as well as rationale for inclusion in this study, will be discussed for each.

First, this project employed videotaped social scenes in order to assess the ability of AsD participants to detect errors in social interactions. Although acted, rather than naturalistic, these scenes were created to depict everyday interactions and real-life, complex social material. Verbal and non-verbal social errors were included in a subset of scenes to evaluate if AsD participants focused on one particular modality when viewing the scenes. In addition, non-social errors, labeled Action Slips, were intended to serve as control stimuli.

A few other studies of AsD have also recently investigated various aspects of performance when presented with videotaped social scenes. Since the initiation of this study, a few investigators have utilized videotaped social interactions in studies of AsD (Channon, Charman, Heap, Crawford, & Rios, 2001; Heavey et al., 2000). Both studies reported impaired ability to process specific aspects of the social information presented in the videotapes. In addition, Klin (2000) examined the processing of ambiguous visual stimuli to assess the attribution of social meaning by individuals with AsD. This group (as well as a group of HFA individuals) demonstrated a lack of sensitivity to the social elements of the video, and provided irrelevant and nonpertinent information in the descriptions. These studies represent a recent shift in methodological approaches to AsD toward naturalistic and more sophisticated techniques.

The AsD participants' ability to recall social stimuli was assessed with a subsequent recognition and recall test for several of the social scenes. When this study was initiated,

there had only been one study (Bowler, Matthews, & Gardiner, 1997) that specifically addressed memory functioning in AsD and results indicated that the group did not utilize semantic context to aid in free recall. Since then, two additional studies (Bowler, Gardiner, & Grice, 2000; Bowler, Gardiner, Grice, & Saavalainen, 2000) have suggested deficits in episodic memory, with relatively stronger performance in semantic memory abilities. The authors hypothesized a potential relationship between the problematic social functioning in AsD and impaired episodic memory. Given the general consensus that the amygdala is an important part of the circuitry underlying social functioning and the known role of this structure in emotional memory, it seems pertinent to investigate social-emotional memory processes in AsD. It is certainly possible that impairment in memory for social information contributes to the impaired development of social abilities.

In addition to the complex social scenes, several less complex stimuli were also investigated. Face recognition and identification are highly specialized in humans and non-human primates and particularly relevant in social functioning. It is well established that humans develop an expertise in face recognition and that specific brain regions, primarily the fusiform gyrus, are associated with this ability (Gauthier, Tarr, Anderson, Skudlarski, & Gore, 1999; Kanwisher, McDermott, & Chun, 1997). Although processing of faces has been hypothesized as a primary area of deficit in AsD, studies that have investigated the accuracy of face perception in AsD have indicated mixed results (Davies, Bishop, Manstead, & Tantam, 1994; Howard et al., 2000). Davies et al. (1994) reported difficulty with face perception, but also found deficits in the processing complex perceptual stimuli, therefore concluding that face processing impairment was due to a

general perceptual impairment. Recently, a series of studies (O'Riordan & Plaisted, 2001a, 2001b) have shown superior visual search in autism and have convincingly argued that this is the result of enhanced visual discrimination. Thus, it seems unlikely that face processing deficits are due to a general perceptual impairment. Rather, the finding of enhanced visual discrimination suggests that difficulty discriminating faces is not consistent with intact perceptual abilities and may be specific to faces. Of course, it will be necessary to expand studies of visual discrimination to include AsD groups.

Furthermore, a recent MRI study (Schultz, Gauthier et al., 2000) suggested that individuals diagnosed with autism and AsD process faces in a similar manner to objects, as opposed to utilizing an 'expert' face system as appears to be the case in healthy controls. Similarly, in young children with autism and PDD-NOS, Dawson, Carver et al. (2002) reported no difference in ERP responding to familiar (i.e. mother's face) versus unfamiliar faces, as opposed to differential responding to familiar versus unfamiliar objects. These two studies indicate that despite results that may indicate "off-line" ability to recognize and discriminate faces, the brain response to face stimuli appears to be abnormal in autism and AsD. These results are consistent with theories that purport a lack of social drive toward social stimuli.

A deficit in the accuracy of face recognition would be consistent with developmental patterns and behavioral features of AsD, as well as with several current theories of AsD. However, evidence thus far has not provided consistent support for a deficit in this area. It is possible that individuals with AsD are able to compensate for a face processing deficit and therefore perform within normal limits on simple tasks that utilize face stimuli. Given the central role of faces in social interaction, as well as suggestion in the

literature that this is an area of abnormal processing in AsD, a face recognition task was included in the present study.

Another type of social stimulus that has been hypothesized as a deficit area in AsD is recognition of emotion expression in others. Empathy has been described as a primary deficit area in AsD and autism (Gillberg, 1992) and a lack of emotion recognition would likely be central to this type of impairment. The ability to accurately recognize and subsequently respond to the emotional tone of a social interaction is the basis of empathy. In order to assess emotion recognition, two tasks were employed: one depicting facial expression and the other presenting voice expressions of emotions.

As with face recognition, recognition of facial expressions has not been investigated extensively in AsD (Dyck, Ferguson, & Shochet, 2001; Howard et al., 2000; Rieffe, Meerum Terwogt, & Stockman, 2000) and findings thus far are equivocal. Critchley et al. (2000) reported differential patterns of cerebral blood flow in autistic individuals compared to normal controls during the presentation of facial expressions. Thus, similar to the face recognition literature, this study suggests that the processing of facial expressions is also abnormal. A recent study by Grossman, Klin, Carter, and Volkmar (2000) reported a verbal bias in AsD, indicating that there was a tendency to attend to words over faces when both were present. Given the possible deficit in processing of facial expressions, this emphasis on language may serve as a compensatory strategy. In everyday social exchange, this type of strategy would result in less attention to facial expressions and more emphasis on the content of language. This would be particularly problematic when facial expression and verbal information are incompatible or when language is not easily interpreted (i.e., irony, puns).

With regard to recognition of emotion in voices, Rutherford, Baron-Cohen, and Wheelwright (2002) recently reported impaired ability to determine mental states based on brief recording from dramatic audio books in a mixed group of HFA/AsD participants. While there was an interaction between performance on the voice task and a control task, the mean difference between the HFA/AsD and control groups was only 4 items (out of 40 possible) and there was overlap in the distributions of scores. Thus, while this finding is suggestive of a relative impairment, improved methodology may clarify this issue. In particular, it is possible that a verbal bias, similar to that reported by Grossman et al. (2000), may have affected performance on this voice recognition task by allowing the participants to attend to the semantic information provided by the phrases. To further investigate this issue, stimuli consisting of incongruent emotional tone and language could be assessed. Another possibility, the one that was selected for the present study, is to assess the recognition of emotion in voices without the influence of meaning by presenting emotional sounding stimuli in the context of nonsense phrases.

In autism, the ability to recognize and identify emotion and mind states in voices has been investigated using various methodology with some results indicating intact ability in this domain (Loveland et al., 1997), and others reporting an impaired ability to use vocal cues (Hobson, 1986a, 1986b; Loveland et al., 1995). Given the mixed results and minimal studies investigating the ability to interpret emotion in AsD, the current study included a facial expression task and a voice expression task.

In addition to emotion recognition, it was important to determine if participants were knowledgeable about the meaning of emotion terms. Although previous work (Baron-Cohen, Jolliffe et al., 1997; Baron-Cohen et al., 2001) suggests that individuals with AsD

are familiar with the meaning of emotion terms, the level of ability in this area has not been measured. Furthermore, the relationship of this ability with performance on emotion recognition tasks has not been explored. In normal development, this type of semantic learning is likely accompanied by learning about other aspects of emotions, such as how they are presented in others and self. However, in AsD, there is some suggestion of a dissociation between understanding the meaning of emotion terms and the ability to process the emotional expression. While other studies have only discussed this semantic emotion knowledge as a side-line (Baron-Cohen et al., 2001) the current study sought to specifically investigate the understanding of emotion definitions in AsD.

In addition to interest in overall level of emotion recognition, the patterns of emotion recognition in AsD will be explored. Recent work (Calder et al., 2001; Gray, Young, Barker, Curtis, & Gibson, 1997; Halligan, 1998; Sprengelmeyer et al., 1996) has demonstrated deficits in identification of specific emotions in populations with known neurological impairments (e.g., Huntington's disease, patients with lesions of the amygdala). There appears to be emerging evidence for the involvement of distinct neural substrates in the recognition of some specific emotions. Examining the pattern of emotion recognition in the AsD group may be useful for addressing theories regarding the underlying neurobiology of this disorder.

As part of the goal of attempting to distinguish verbal and nonverbal elements of social processing in AsD, a novel task presenting brief nonverbal gestures and actions in a video format was also included. The goal of this task was to directly explore the ability of AsD individuals to understand information that was presented in a strictly nonverbal manner. Given that nonverbal expression and gestures are reported to be atypical in AsD

and autism (Tantam et al., 1993) it is possible that a lack of understanding of this form of communication is also present. Again, the issue of complexity was addressed by including three types of stimuli: simple gestures that did not involve emotional content, as well as "simple" and "complex" emotional items that incorporated an emotionally laden message. This task also offered an opportunity to assess the ability to recognize emotion when presented with various nonverbal cues; this has not been previously investigated in AsD.

In summary, the current study surveyed the social processing domains discussed above in a group of individuals with AsD. The primary goal of this project was to improve the current understanding of social processing in AsD by varying the complexity, modality, and type of social stimuli and thus, offering a new set of comparisons and perspectives of this disorder. Results were expected to offer some preliminary support for one of two broad accounts (i.e., core social impairment versus associative deficit) of the underlying deficit in AsD. Importantly, findings were expected to reveal the next steps in a systematic program of research focused on illuminating and defining the core deficit(s) in this diagnostic group.

Method

Participants

A total of 20 individuals participated in this study: 11 with a diagnosis of Asperger's Disorder (AsD) and 9 normal controls (NC). All individuals in the AsD group were diagnosed based on DSM-IV criteria (American Psychological Association,

1994). Nine of the 11 participants were diagnosed with AsD by a team of experienced clinicians from the Queen Alexandra Centre for Children's Health (QACCH) in Victoria, British Columbia, Canada. This team typically included a psychiatrist and psychologist experienced in the diagnosis of Pervasive Developmental Disorders. In addition, this study further investigated symptoms utilizing a Behavioral Questionnaire completed by parents of AsD participants. This scale comprised a combination of selected questions from the Australian Scale for Asperger's Syndrome (Garnett & Attwood, 1998) and the Asperger Syndrome Diagnostic Interview (ASDI, Gillberg, Gillberg, & Ehlers, 1991). This questionnaire assisted with the validation of diagnosis, as well as serving as a measure of severity. The Social Skills Rating Form (Gresham & Elliot, 1990) was also completed by parents for both groups in order to assess current level of social functioning.

Furthermore, the principle investigator previously completed a thorough file review of all patients at QACCH with a diagnosis on the Pervasive Developmental Disorder spectrum. Thus, the developmental, diagnostic, and treatment histories of most participants were familiar. Based on all of the sources described above, AsD was deemed to be the appropriate diagnosis in all cases included in this study.

Participants in the AsD group were recruited through the QACCH. The Research Committee at QACCH and the Human Research Ethics Committee at the University of Victoria approved all aspects of this project, including recruitment of AsD participants via a letter. This letter was mailed to potential participants as part of an Asperger's Disorder Parent Support Group monthly newsletter. The letter described the study and invited the individual with Asperger's Disorder and his/her family to participate. In

addition, the study was announced in the newsletter and described at several support group meetings. This support group is a free service offered by staff of the QACCH. When a parent made initial contact with the project coordinator, the study was described in more detail. If the family and individual diagnosed with AsD were interested in participating, an initial session was scheduled.

The two participants that were not previously evaluated and diagnosed at QACCH contacted the study coordinator after hearing of the study from another participant's family. Both of these individuals were diagnosed with AsD by a reputable psychiatrist in the community. Again, the appropriateness of the diagnosis was explored during an informal interview with the participants' parents, via the Developmental History Form, by evaluating clinical presentation during testing, and completion of the Behavioral Questionnaire. One of these individuals was a young adult and although the target age range was 10 – 18, he was included because enrolling the anticipated number of adolescents proved difficult and preliminary analyses indicated a lack of age effects for all experimental measures.

The Normal Control group was recruited from several public schools within the Greater Victoria School District. After initial ethics approval was granted, several schools agreed to allow the principal investigator to give a brief talk about AsD and a description of the study to groups of students (typically psychology classes). Following this talk, interested students were given a letter explaining the project and a consent form to take to their parents. If the consent form was signed by a parent or guardian and returned to the school, a cognitive screening was completed. This session included the Vocabulary and Block Design subtests from the Wechsler Abbreviated Scale of

Intelligence (WASI, 1999) and the purpose was to attain an estimated level of intellectual functioning (i.e., IQ). During the talk and in the letter describing the study, it was explained to students and families that not all volunteers would be asked to participate, as only age, gender, and IQ matched individuals were needed. All interested students completed the cognitive screening and they were each told that they would be contacted and invited to participate in the remainder of the study if they matched one of the participants with AsD. As the AsD group developed, NC participants were selected from this pool of students based on the key demographic variables. The majority of the control volunteers were female, but males were primarily needed as the AsD group consisted of 10 males and 1 female. All participants, both AsD and NC, were offered a small honorarium ($25.00) that was paid at the end of the final session.

The age range of the participants was 10 years to 28 years. The majority of these were in the target age range of 10-18 years (17/20). Demographic information and behavioral ratings for all participants are shown in Table 1. One-way ANOVAs revealed no significant differences between the groups on age, education, Vocabulary t-score, or Block Design t-score.

Twenty-two participants initially began the study, but one AsD participant and one NC participant completed only one testing session. The AsD participant was described as highly anxious by the examiner and refused to return for a second testing session. The NC participant was unable to be contacted after the first session. These participants were not included in the data analyses.

Table 1

Demographic Characteristics and Behavioral Ratings of Participants

	Asperger's Disorder (N = 11)		Normal Controls (N = 9)	
	Mean	SD	Mean	SD
Age	16.3	4.8	16.0	4.6
Education	9.9	2.8	9.8	3.2
Vocabulary T-Score	60.2	7.8	59.4	6.3
Block Design T-Score	54.7	8.1	57.8	9.3
Social Skills Rating Scale				
Social Scale (SS)	77.5 (n=8)	13.4	106.9 (n=7)	8.6
Problem Scale (SS)	120.3 (n=8)	16.5	95.6 (n=7)	9.0
Behavioral Questionnaire	122.8 (n=8)	10.7	--	--
Mean Rating (0-6)	4.7	--	--	--

Note: The Social Scale and Problem Scale are reported in Standard Scores (SS); the normative mean is 100 and the normative SD is 15 points. The Behavioral Questionnaire data is the mean of the raw scores on this measure; the maximum possible score is 156. For all items, 0 indicates rarely (i.e., not a problem behavior) and 6 indicates frequently (i.e., definitely a problem).

Design and Procedure

All testing for the AsD participants was completed individually in a quiet room at the University of Victoria, Department of Psychology. During the initial visit, the WASI was completed first. If the individual scored at or above a Full Scale IQ of 85, further testing was completed. All AsD participants who volunteered for the study met this criterion and were included in the study. The initial cognitive screening session (i.e., WASI testing) for some control participants was completed individually in a quiet room within the school setting. For other students, the option of testing at school was not available and they were screened at the University of Victoria.

Parents of all individuals with AsD were given several forms to complete. Data from these measures was used to confirm diagnosis, to investigate relative level of severity, and to record family history for potential future investigations. Following is a brief description of the forms completed by parents of the AsD group.

1. Developmental History Form. This included questions regarding pregnancy, delivery, childhood heath history, developmental milestones, social development, school history, and psychiatric history. A copy of this form is attached; see Appendix A.
2. Family History Form. This included questions regarding relevant family history, including all relatives who have a history of learning problems, attention problems, psychiatric disorders, social difficulties, or medical issues. A copy of this form is attached; see Appendix B.
3. Social Skills Rating Form (Gresham & Elliot, 1990): This is a standardized measure of social functioning, comprised of two subscales: Social Skills and

Problem Behaviors. Two versions are available: Secondary Level (Grades 7-12) and Primary Level (Grades K –6). Normative data is not available for adults and therefore, this measure was not used for the adult participants.

4. Behavioral Questionnaire: This includes questions pertaining to common symptoms and behaviors in individuals diagnosed with Asperger's Disorder. Selected questions from the Australian Scale for Asperger's Syndrome (Garnett & Attwood, 1997) and the Asperger Syndrome Diagnostic Interview (ASDI; Gillberg, Gillberg, & Ehlers, 1991) were combined to form this questionnaire. These two measures have substantial overlap and therefore asking parents to complete both questionnaires would be redundant. However, because each contained some unique questions, they were combined to form a more complete questionnaire, comprised of 26 questions. Parents were asked to rate their child on a 0 to 6 point scale for each item. A response of 0 indicated *Rarely* and a response of 6 indicated *Frequently*. The questionnaire is included in Appendix C.

Parents of the individuals in the NC group were also asked to complete the Developmental History Form and Social Skills Rating form. The Family History Form was developed to investigate possible genetic factors of the participants diagnosed with Asperger's Disorder and was therefore not included in the packet for the normal controls. Similarly, the Behavioral Questionnaire was included in order to further substantiate diagnosis, as well as evaluate the relative severity of AsD symptoms. Thus, this measure was not relevant to the NC group.

The testing was completed in a minimum of two sessions and for some participants a

maximum of four sessions. This varied among individuals according to the speed of task completion and the amount of time per session that they were able to perform at an optimal level. A typical testing session lasted approximately two hours. Normal control subjects completed the testing in an average of four hours, while the AsD participants typically required approximately 5-6 hours.

The majority of participants were tested by a research assistant. The principle investigator (SJ) initially trained two research assistants (one clinical graduate student and one undergraduate honors student) and tested the first two participants in the presence of these research assistants. Two additional research assistants were hired later and were trained by one of the original research assistants. One research assistant (SK) served as the project coordinator and tested the majority of participants.

Tasks and Testing Procedures. Each participant was administered the following tasks, in order:

1) WASI: Vocabulary and Block Design
2) Social Scenes
3) Memory for Social Scenes
4) Nonverbal Signals
5) Emotional Definitions: Spontaneous and Multiple Choice
6) Face Recognition - Rating Trial
7) Global/Local
8) Facial Recognition - Recognition Trial
9) Facial Expressions
10) Voice Expressions

Each of these tasks, excluding the WASI, will be described in detail.

Social Scenes. This task consisted of 50 brief videotaped scenes involving social interactions between two or more individuals. See Appendix D for a brief description of each scene. Undergraduate theatre majors were recruited and paid to perform as actors for the production of this task. For each scene, the actors were given a description of what the scene was to entail. The flow of the scene was then typically discussed among the group of actors and the principal investigator, and a general outline of the scene was developed. The actors were not asked to learn a specific dialogue, but rather to perform impromptu based on the goal of each scene. All scenes were filmed in a small "studio"; the props, background, and angle of scenes was changed frequently so as to depict a variety of settings. Four types of scenes were produced:

1. Normal interactions. Normal scenes involved two or more actors engaging in a social interaction intended to appear normal. The actors were instructed to interact normally with regard to both verbal and nonverbal social interactions.
2. Abnormal – Nonverbal. This subset of abnormal interactions was intended to appear atypical with regard to nonverbal social interaction. When these scenes were filmed, the actors were asked to interact abnormally, but only with regard to one specified aspect of nonverbal behavior. The nonverbal target areas included eye contact, prosody, proximity, posture, turn-taking, and facial expression. The actors attempted to depict the extremes of each of these nonverbal behaviors (i.e., too much eye contact in one scene, lack of eye contact in another).
3. Abnormal - Verbal Faux Pas. This set of scenes involved violations of social rules by way of verbal communication. In other words, scenes depict a verbal

faux pas, in the presence of normal non-verbal communication. The actors were directed as to the content of the faux pas and were asked to fit this into a short scene in the most natural way possible. These were typically the most difficult scenes to complete, as a verbal faux pas is difficult to depict naturally when acting.

4. Abnormal - Action Slips. These scenes were normal with regard to social interactions, but depicted an action slip. An action slip was defined as a mistake that is not social in nature. For example, handing someone the wrong item or leaving something behind when this was clearly not intended. These scenes were conceptualized as control items in order to determine if participants were able to detect abnormalities that were not social in nature.

Four filming sessions were completed and following each session the new set of scenes was viewed by 3 - 4 undergraduate students. This was done in order to determine if socially intact individuals could easily delineate between the normal and abnormal scenes and to determine if they were able to detect the intended abnormalities. In addition, after the first filming session, two adolescents viewed the scenes. This was done in order to confirm that individuals in this age group were able to perform in a similar fashion to the undergraduates. The adolescents responded in a very similar fashion to the undergraduates in terms of percent correct and detection of abnormalities, suggesting that the scenes were appropriate for the target age group.

The primary goal of these pilot studies was to select a set of scenes that normal participants could easily identify as abnormal. In addition, it was important that the majority of pilot subjects agreed on the incorrect aspect of the scene. Scenes that were

difficult for the normal individuals during the pilot phase or those that elicited various qualitative responses were discarded. Of approximately 70 original scenes, 50 were selected for the final video. The video included 15 Normal Scenes, 16 Abnormal Nonverbal, 10 Action Slips, and 9 Abnormal Verbal Faux Pas scenes.

Each scene was edited in order to select an appropriate beginning and ending point and to help with clarity and professional appearance of the video. Forty-nine of the scenes range from 5 seconds to 40 seconds in duration. One scene was longer relative to the others, for a total of 75 seconds. The editing work was completed by Television Services at the University of Victoria. The author was present and assisted with all aspects of this process. The 50 scenes were initially randomized and then fixed on the final video in this random order with 10 seconds of blank video between each scene.

During testing, participants were seated in front of a 14-inch television monitor, approximately 3 feet away from the screen. The examiner operated a remote control in order to start and pause the video presentation. An audio recorder was used to record the participants' narratives during the test. The examiner presented the following instructions to each participant:

*You are going to watch a set of short scenes, which involve interactions between two or more people. Some scenes will be normal and some scenes will be abnormal. The abnormal scenes can be incorrect for a variety of reasons; for example, it may have to do with how the people are interacting or it could be related to what they are doing. You need to decide if the scene is normal or abnormal. If you think it is abnormal, tell me what is incorrect about it. In addition, please rate how abnormal the scene was: this is the rating scale I want you to use (*show participant the rating scale*), with 1 being slightly*

abnormal and 10 being very abnormal.

It is important that you think out loud while you are watching the scenes. Talk about what you are seeing and what you are thinking about the scene. I want you to tell me whenever you see something wrong in the scene; Please tell me to pause the video when you would like to point out something that is incorrect. When it's paused, tell me what was wrong. If you need to watch the scene more than once, I can rewind it for you. I will attach a microphone to your shirt, so that I can record your responses. Do you have any questions?

While participants watched the video, the examiner recorded the time at which the video was paused and what the subject said during each of these pauses. In addition, if the scene was viewed more than once, this information was recorded. After watching the video, each participant was asked to decide whether the scene was normal or abnormal. If abnormal, s/he was asked to describe what was incorrect about the scene and then to rate the level of abnormality (1 – 10 scale described above).

Each of the 50 scenes was scored as correct (1 point) or incorrect (0 points) according to whether the participant correctly labeled the scene normal or abnormal. A total percent correct out of a total of 50 possible points was calculated for each participant and this score was labeled Video Identification (Video ID). Percent correct was also calculated for each of the 4 subtypes of scenes, as well as for the combined 35 Abnormal Scenes (Abnormal ID).

Memory for Scenes. A set of 9 scenes was randomly selected from the 50 scenes viewed by the participants. In addition, one scene that was not included in the set of 50 was included as a foil. The first few seconds of each of the original scenes (3-4 seconds)

was copied and these 10 abbreviated scenes were randomly ordered and then recorded onto the videotape.

Following the social scenes task, each participant was shown this set of clips and asked to indicate if s/he recalled the scene from the previous set. If a yes response was given, the participant was asked to give a brief description of what happened in the original scene. Responses were recorded verbatim by the examiner on a written score sheet.

Similar to the Social Scenes, a 1 or 0 point was assigned to the initial recognition response. Thus, each participant received a Memory Recognition Score ranging from 0-10. The description of the scenes was rated on a three point scale. A score of 0 indicates that the participant misidentified the scene (i.e., described the events of another scene). A 1-point response indicated that s/he was able to identify the characters or a small part of the scene, but was unable to describe the salient features including the key parts of the social exchange. A 2-point response required a description that highlighted the key aspects of the original scene and clearly separated the scene from the others. A maximum of 18 points was possible for the Memory Recall Score, as one item was a foil.

Nonverbal Signals. The same group of undergraduate actors performed a set of nonverbal signals. These brief videotaped presentations depicted gestures, intended to communicate a message in a strictly nonverbal manner. There were no vocalizations in any of these items. Each nonverbal signal was approximately 2-3 seconds in length. These were filmed in 2 sessions and were again viewed by several undergraduate students after each session. These students were asked to identify the message that the person in the video was attempting to communicate. Again, based on this pilot testing,

some items were discarded and others were filmed a second time to improve quality. A final group of 30 nonverbal signals were selected. There were three types of nonverbal signals and they were conceptualized in the following way:

1. Non-emotional. These were nonverbal signals that did not involve facial expressions and did not contain any emotional content. This set of gestures conveys meaning even when all other non-verbal expressions are neutral. For example, indicating that you want someone to "wait for a second" by putting up your index finger, is understood without the addition of any additional verbal or non-verbal information. Other examples include putting a finger to one's lips to indicate "shhhh", making an "OK" signal, waving goodbye, or holding one's hand out to indicate "I want some".
2. Simple Emotional. These nonverbal signals are emotionally-laden, are naturally accompanied by a particular facial expression, but consistently have only one meaning. For example, when a person wrings his/her hands in a particular manner, this depicts anxiety or distress, but is also accompanied by a certain facial expression or body posture that offers additional information. It is hypothesized that this set of nonverbal signals can be identified from body language alone. Thus, understanding facial expressions is not necessary to discern the meaning, but likely serves as useful additional information.
3. Complex Emotional. This set of nonverbal signals also depicted emotionally laden gestures. These were complex in that they could have several meanings depending on additional nonverbal cues such as body language, facial expression, or other nonverbal cues. Therefore, to correctly identify the meaning of these

signals, one must rely on facial expression or other nonverbal information. For example, tapping one's finger on a desk could signify boredom, deep thought, or annoyance. In order to decipher the message, other information is important. For this example, the actor's expression indicated that she was feeling annoyed or impatient, thus offering the critical clue in deciphering the message she was communicating.

Thirty nonverbal signals were included: 14 non-emotional, 7 simple emotional, and 9 complex emotional items. Participants were asked to identify the nonverbal message communicated by the actor and verbatim responses were recorded by the examiner on a written score sheet. Participants were allowed to view the nonverbal signals as many times as needed. The examiner recorded the number of times a scene was repeated. A particular response was expected for each item based on what the actor was instructed to present. However, if an alternative or similar response occurred several times in the NC group, this response would also be considered correct. Thus, a narrow range of responses was deemed correct for each item. If a participant's response was considered to fall within this range, s/he received one point for the item. A total overall score based on either a score of 1 or 0 for each item was calculated. Three subscale scores were also derived, one for each subset of non-verbal signals. A list and brief description of the nonverbal signals is presented in Appendix E.

Emotional Definitions: Spontaneous and Multiple Choice. A set of 18 emotion definitions was developed and pilot data was collected on several undergraduate students and adults, as well as two adolescents. This set was then edited by discarding some definitions, adding a few new items, and rewording several initial items. This yielded a

final set of 20 emotion definitions.

Participants were asked to read a set of twenty Emotion Definitions that were presented to them on paper in a typewritten format. Each item was intended to describe a specific emotion, unique from the others. For the Spontaneous version, participants were asked to respond to each item by writing the word that best fit the definition. They were then asked to complete the Multiple Choice form of the Emotion Definitions. This form contained the same definitions, but four choices were presented this time. Participants were instructed to circle the emotion term which best described the definition presented. Appendix F contains a copy of both versions of this task.

Spontaneous items were scored as correct (score = 1) if the participant indicated the target emotion or a synonym (i.e., envy for jealousy); all other responses were scored as incorrect (score = 0). A total percent correct was then calculated for each participant. For the Multiple Choice format, a score of 1 or 0 was again given to each item and a total percent correct was calculated for each participant.

Face Recognition - Rating Trial. Participants were seated in front of a 14-inch computer monitor and were instructed to look at a set of faces and rate each face based on pleasantness. The set contained 20 faces selected from a larger set of face stimuli developed by Cindy Bukach at the University of Victoria. Digital photos of a large group of undergraduate students were taken, while wearing a black swim cap in order to remove all variability based on hair. Each digital photo was then cropped and "touched up" using the software program PhotoShop in order to remove any features (such as moles, blemishes, etc.) that might differentiate the faces in a manner other than basic facial features (eyes, nose, mouth, etc.).

Each face was presented for 500 ms and the participant was asked to rate the pleasantness of the face on a scale of 1 – 6, with 1 indicating "very unpleasant" to 6 indicating "very pleasant". Each trial was initiated by the examiner after the subject had completed his/her rating. The participants were not told to remember the faces.

Face Recognition Task. The Global-Local Task was then administered (described below) and was followed by the Recognition component of the Face Recognition task. During the recognition trial, participants were shown a set of 40 faces, 20 from the original set that were rated for pleasantness and 20 foils. They were asked to indicate whether the face was one that they saw before, in the original set, or one they had not seen before. The examiner entered participants' responses on the computer keyboard and results were saved on the computer hard drive.

Global/Local. There were three types of stimuli for the Global-Local task: Consistent - large letters comprised of identical smaller letters; Inconsistent - large letters comprised of a set of different smaller letters; and Neutral - a large letter comprised of stars (*).

Two tasks were administered and the order in which they were administered was counterbalanced by participant within the groups, with 11 of the participants completing the Local task first and 9 completing the Global task first.

The Global task required the participants to identify the large letter as quickly as possible. A practice session consisting of 3 items was administered. All participants appeared to understand the task after completing the practice items. A microphone was attached to the participants' shirt and they were asked to speak loudly and clearly. The microphone was attached to a voice key that recorded the voice onset of the participant.

The examiner recorded errors, such as coughing or saying something other than a response to the stimuli. At times, the voice key did not respond the first time that the participant voiced an answer. The examiner also recorded the participant's response, in order to evaluate error rates (i.e., stating an incorrect response).

The Local task involved the same stimuli, but this time the participant was asked to identify the small letters or to say "star" if the large letter was comprised of stars. Again, a practice session of 3 trials was completed and repeated if necessary.

There were 72 trials for both the local and global tasks, 24 consistent stimuli, 24 inconsistent, and 24 neutral stimuli. The stimuli stayed on the screen until the participant responded. Following the voice key response, there was a 500 ms ISI between items.

The critical dependent measure for these tasks is response time. After "known" voice key errors were omitted, the mean and standard deviation of the response times for the two tasks was calculated for each participant. Any response time that was more than 2 standard deviations from the mean was discarded because it was assumed that these were outliers, likely due to voice key problems that were not obvious to (or missed by) the examiner. The response times were then divided into three groups based on the type of stimuli: consistent, inconsistent, and neutral. Thus, there were six sets of data for each participant for this task.

Unfortunately, there were many technical problems with the voice key during this task and there were a large proportion of errors and long response times that appeared secondary to this problem. Given the small number of trials that were included in this task and the large number of items that were discarded due to voice key errors, the remaining data set was small and was likely not an accurate reflection of true

performance. Therefore, results of this task were not included in the statistical analyses.

Face Expression. A subset of the Ekman and Friesen (1976) emotional expression photos was digitized and presented to participants in a computerized format. These photos depict 6 different emotions, sadness, happiness, anger, surprise, disgust, and fear. In addition, a set of neutral faces was included. Six different photographs were selected for each of the 7 emotions. Each of these 6 photographs depicted a different actor modeling the target emotion - three were women and three were men. Thus, a total of 42 emotional expression photos were included and each photo was presented 3 times throughout the task, for a total of 126 trials.

Participants' were seated in front of a 14-inch computer monitor. They were given a type-written list of the seven emotion terms, presented in alphabetical order. They were instructed to look at each photograph and identify which of the terms best described the facial expression presented by the actor in the photo. The 126 trials were randomized for each participant. Each facial expression was presented until the participant responded. Responses were recorded by the examiner by typing the answer on the computer keyboard. Data was stored in a file on the hard drive. Following the participants' response, each subsequent trial was initiated by the examiner.

The total percent correct was calculated for each participant. In addition, the responses for each emotion were examined separately and percent correct for each emotion was calculated. Finally, an error analysis was completed for this task and a confusion matrix was produced in order to investigate the types of errors made by the participants (i.e., what emotions were confused with others).

Voice Expression. The vocal expressions were produced by three actors (1 male, 2 female) and each item was intended to depict a specific emotion. The actors presented the emotion within the context of a sentence consisting of normal intonation and structure, but comprised of nonsense words (e.g. Be mace the sneep unsped). These stimuli were developed prior to the onset of this project under the direction of Daniel Bub, Ph.D. The original recordings depicted 13 different target emotions or emotional states. For the purpose of this study, this larger set of recordings was normed on a set of 22 undergraduate students at the University of Victoria to determine the level of difficulty and validity of each voice expression. The goal was to develop a subset of voice expressions that were relatively easily identified by undergraduates, but not so easy as to create a ceiling effect. After the completion of the pilot study, a set of 32 voice expressions was selected. Three of the initial categories were found to overlap with another category: depression with sadness, contempt with disgust, and panic with fear. As a result, these 3 pairs were collapsed into 3 categories (sadness, disgust, and fear). Thus, there were a total of ten emotion categories included in the final design: anger, anxiety, boredom, disgust, excitement, fear, happiness, interest, pride, sadness. Three items for each emotion were selected, with the exception of Disgust and Sadness; there were four items for these emotions. There were an equal number of male (16) and female voices (16). Each voice expression was presented three times, for a total of 96 trials. These 96 trials were presented in a randomized order for each participant.

Participants were seated in front of the 14-inch computer monitor. A type-written list of the 10 emotions presented in alphabetical order was placed near the computer screen. The participants were instructed to listen to each item and to determine which of the 10

emotions was depicted by the actor's voice. The voice expression recordings ranged from 750 to 1200 ms in duration. Each new trial was initiated by the examiner after the participant selected a response. The examiner recorded responses by typing the answer on the computer keyboard. Data was stored in a file on the hard drive.

Percent correct score was calculated for each participant. The responses for each emotion were examined separately and the percent correct for each emotion was calculated. An error analysis was completed and a confusion matrix was produced.

Results

The group performance of the AsD participants was compared to the performance of the NC group for each of the seven Social Processing tasks. Correlations between the target tasks and selected demographic variables were then completed to investigate the pattern of associations among the Social Processing tasks. The two groups' correlation matrices were examined independently. Finally, for the purpose of generating hypotheses for future studies, selected analyses further explored specific findings within the group comparisons as well as additional relationships among measures.

All of the Social Processing tasks exhibited satisfactory psychometric properties, including relatively normal distributions. Individual participant data for each task are presented graphically for the two groups (see Figures 1 - 9) to highlight the distributions for each measure.

Group Comparisons

Given the goals of this study and the small sample size, a significance level of $p < .05$ was selected for all group comparisons. Both one-tailed independent samples t-

tests and non-parametric (Mann Whitney U-tests) statistics were utilized to compare groups. In all cases, the results for these two comparisons were very similar and therefore only the one-tailed parametric results are reported for most tasks. Group means and standard deviations, as well as the t-values, for each group comparison are presented in Table 2.

Social Scenes. The 50 Social scenes were divided into the 35 Abnormal scenes, which included Nonverbal, Verbal Faux Pas, and Action Slip errors, and the 15 Normal scenes. The Normal and Abnormal scenes were analyzed separately. With regard to the Normal scenes, both groups correctly labeled these scenes with a high level of accuracy; there was no difference in group performance on this subset of scenes.

The measure labeled Abnormal Scenes Identification (Abnormal ID) reflected whether a subject was able to accurately identify the scenes that contained social (Nonverbal and Verbal Faux Pas) and non-social (Action Slips) errors by stating that the scene was "abnormal". The AsD group's performance was significantly worse than that of the NC group, $t(18) = -2.04$, $p < .05$, indicating that they stated error scenes were "normal" with a higher frequency. Figure 1 illustrates the considerable range of scores for the AsD group, in contrast to the less variable scores of the NC group.

Nonverbal Signals. Statistical comparison of group performance yielded significant results, $t(18) = -3.57$, $p < .01$, indicating that the AsD group was less accurate than that NC group when asked to define the message intended by the presentation of brief Nonverbal Signals. As can be seen from Figure 2, the NC group demonstrated a relatively narrow range of scores, with all participants performing above 70 percent correct and 8 of 9 scoring at or above 80 percent correct. The AsD participants

Table 2

Group Differences for the Social Processing Tasks Between the Normal Control Group and the Asperger's Disorder Group

Task	NC Group M	NC Group SD	AsD Group M	AsD Group SD	t
Social Scenes					
Normal Scenes	89.6	8.9	90.9	8.0	.36
Abnormal Scenes	73.2	11.6	55.5	23.9	-2.04*
Nonverbal Signals	84.9	6.1	69.6	11.5	-3.57**
Memory for Scenes					
Recognition	86.7	12.2	82.7	16.8	-.59
Recall	79.8	13.5	54.6	25.5	-2.69**
Emotion Definitions					
Spontaneous	65.0	18.4	67.7	20.2	.31
Multiple Choice	94.4	5.8	85.9	16.1	-1.51
Face Recognition	69.7	8.5	61.8	8.5	-1.67
Face Expression	85.4	7.2	78.7	9.0	-1.81
Voice Expression	63.2	9.0	53.7	9.1	-2.33*

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

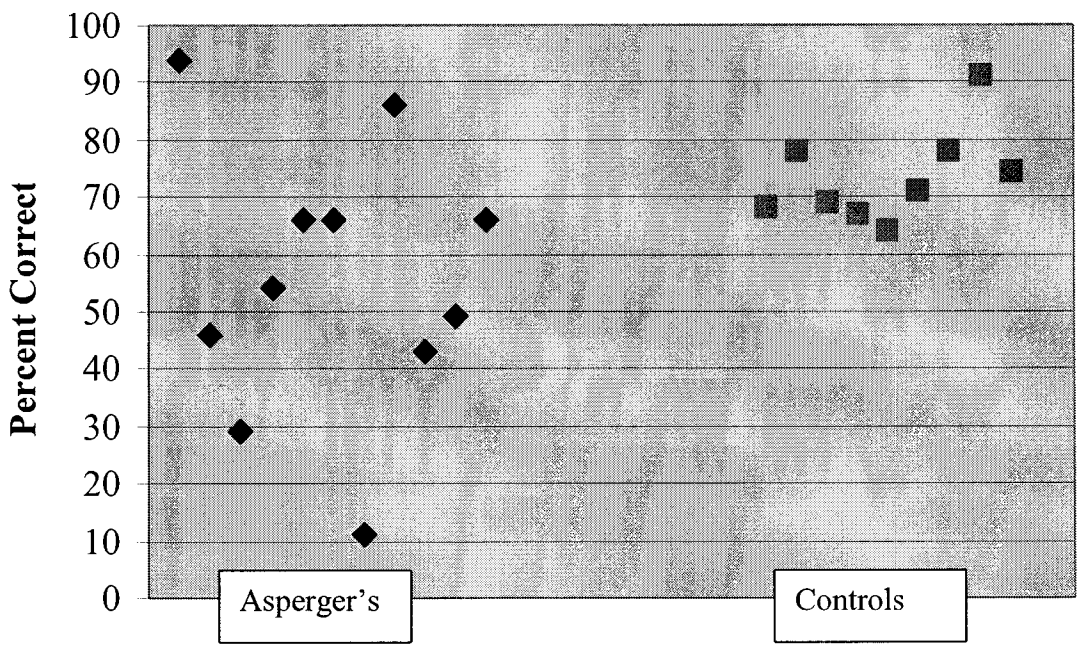

Figure 1. Participant scores on the Abnormal Scenes Identification measure of the Social Scenes task.

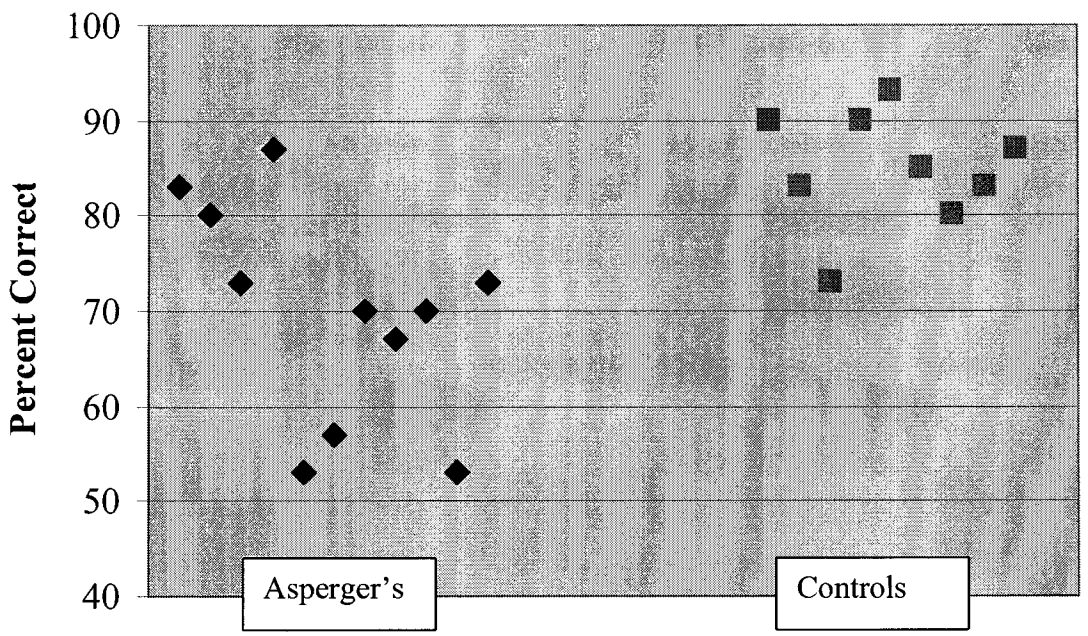

Figure 2. Participant scores on the Nonverbal Signals task.

demonstrated a broader range of scores with nearly all individuals performing below the mean (84.9) of the NC group.

Memory for Scenes. Both the Recognition and Recall measures of the Memory for Scenes task were examined. On the Recognition task, most participants were able to recognize that they had watched the scene previously. There was one individual in the AsD group who scored at chance (50 percent correct). Figure 3 depicts the performance of the two groups, revealing nearly identical performance on this measure, with the exception of two AsD participants.

As can be seen in Figure 4, the Memory for Scenes Recall measure yielded a different pattern of results. Group comparisons revealed a significant difference, $t(18) = -2.69$, $p < .01$. Although, the AsD group demonstrated intact ability to recognize that they had previously viewed the scenes, their poor performance on the Recall measure indicates difficulty correctly identifying and recalling the details of each scene. There was a great deal of variability within the AsD group, with scores ranging from 22 percent correct to 100 percent correct, while the range for the NC group was more restricted (67 – 100 percent).

Emotion Definitions. Both the Spontaneous and Multiple Choice versions of Emotion Definitions were examined. Figure 5 shows the variability demonstrated by the NC participants when asked to spontaneously define a list of 20 emotion words, with scores ranging from 30 to 100 percent correct. There was no difference between groups on the Spontaneous version of the task.

On the Multiple Choice version of the task all NC participants demonstrated improvement with the addition of the 4 choices. In contrast, compared to scores on the

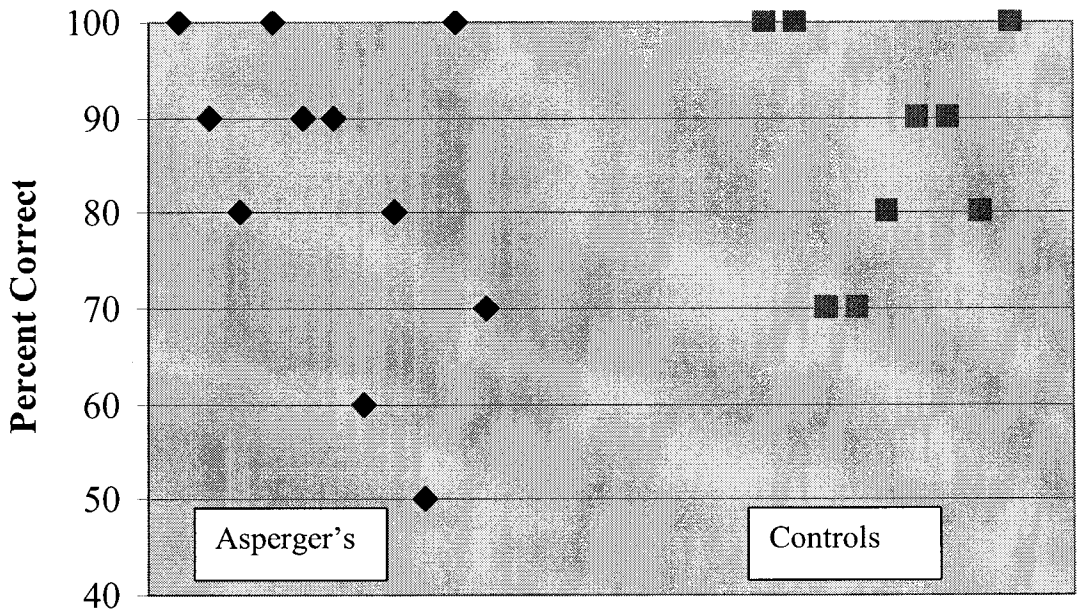

Figure 3. Participant scores on the Recognition version of the Memory for Scenes task.

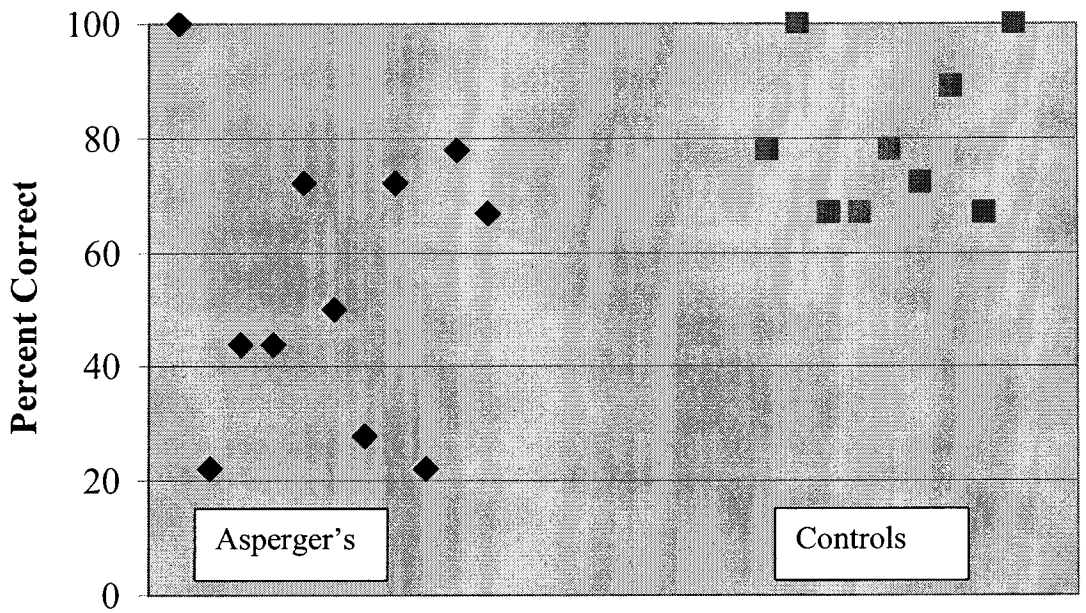

Figure 4. Participant scores on the Recall version of the Memory for Scenes task.

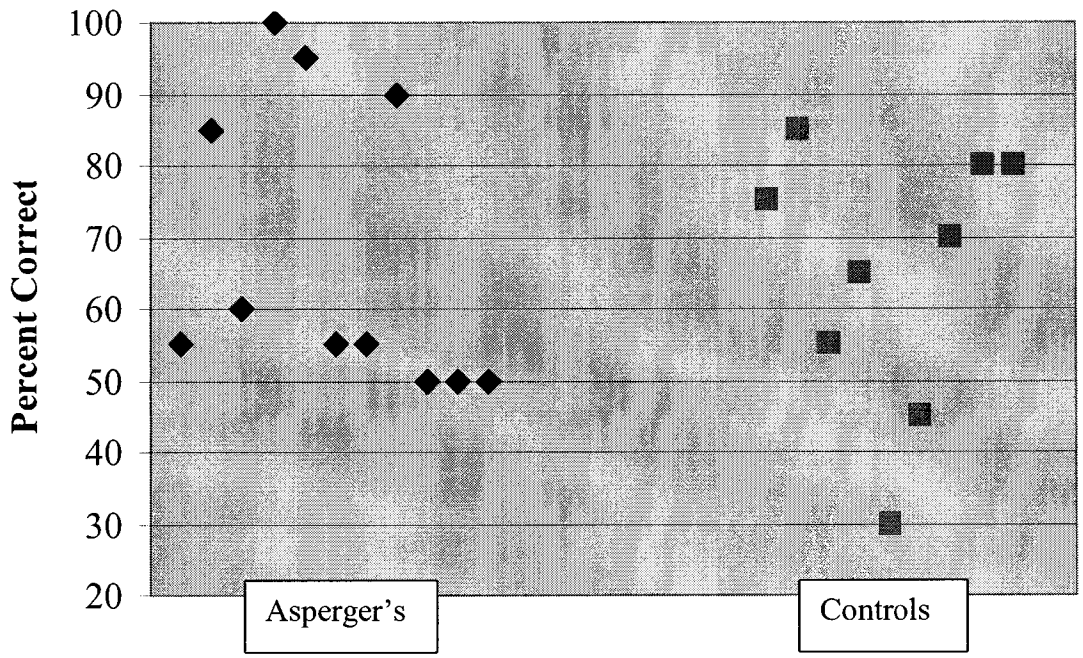

Figure 5. Participant scores on the Spontaneous version of the Emotion Definitions task.

Spontaneous version, 7 AsD participants showed improvement, 3 AsD participants demonstrated worse performance, and the remaining participant's score did not change. The group difference did not reach significance. The percent correct for each participant is presented in Figure 6.

Face Recognition. The difference between groups was nearly significant, $t(18) = -1.67$, $p = .06$. Figure 7 illustrates the distribution of scores on this task, showing distinct patterns of group performance with most NC participants performing at or above 70 percent correct and most AsD participants scoring below this level.

Face Expression. The parametric comparison of group performance on the Face Expression task indicated a significant difference, $t(18) = -1.813$, $p < .05$. For this task, the Mann-Whitney U-test was not significant, but was at trend, $U = 29.5$, $p = .07$. Figure 8 depicts the greater distribution of the AsD group's performance relative to the NC group.

Voice Expression. Comparison of group performance on this task also indicated a group difference, $t(18) = -2.33$, $p < .05$. Figure 9 illustrates the group difference on the Voice Expression task, showing only minimal overlap in the distributions of performance.

Summary of Group Comparisons. Overall, statistical comparisons of group performance indicated that the AsD group performed more poorly than the NC group on the following tasks: Face Expression, Voice Expression, Nonverbal Signals, Abnormal Video Identification, and Memory for Scenes Recall. Group comparison for the Face Recognition task indicated a trend towards significance. There was no difference between groups on the Emotion Definitions task.

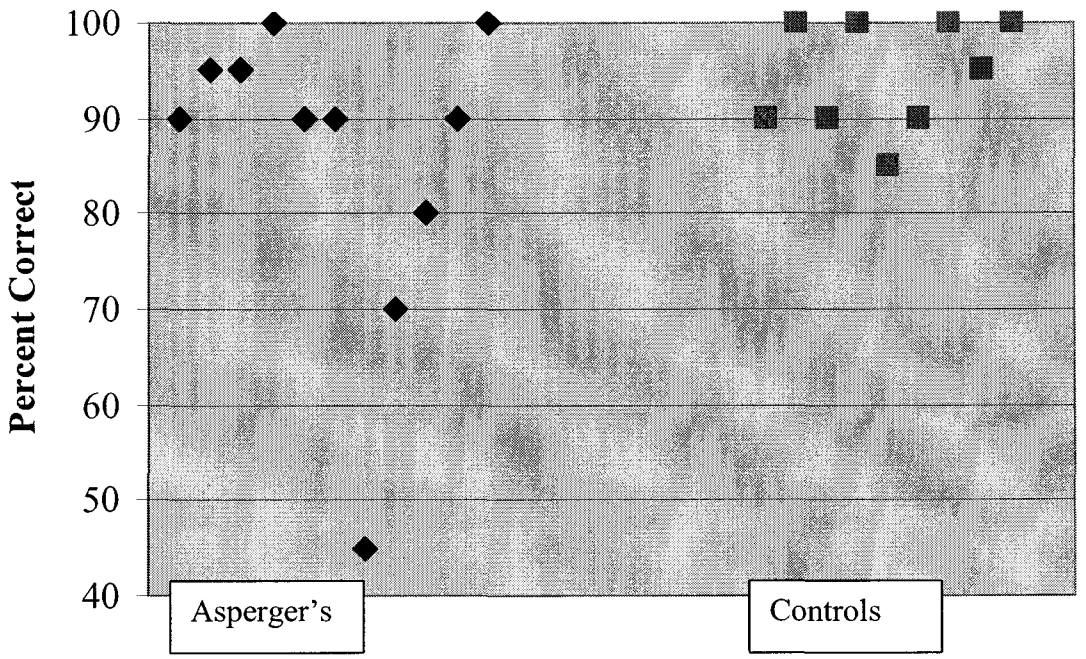

Figure 6. Participant scores on the Multiple Choice version of Emotion Definitions task.

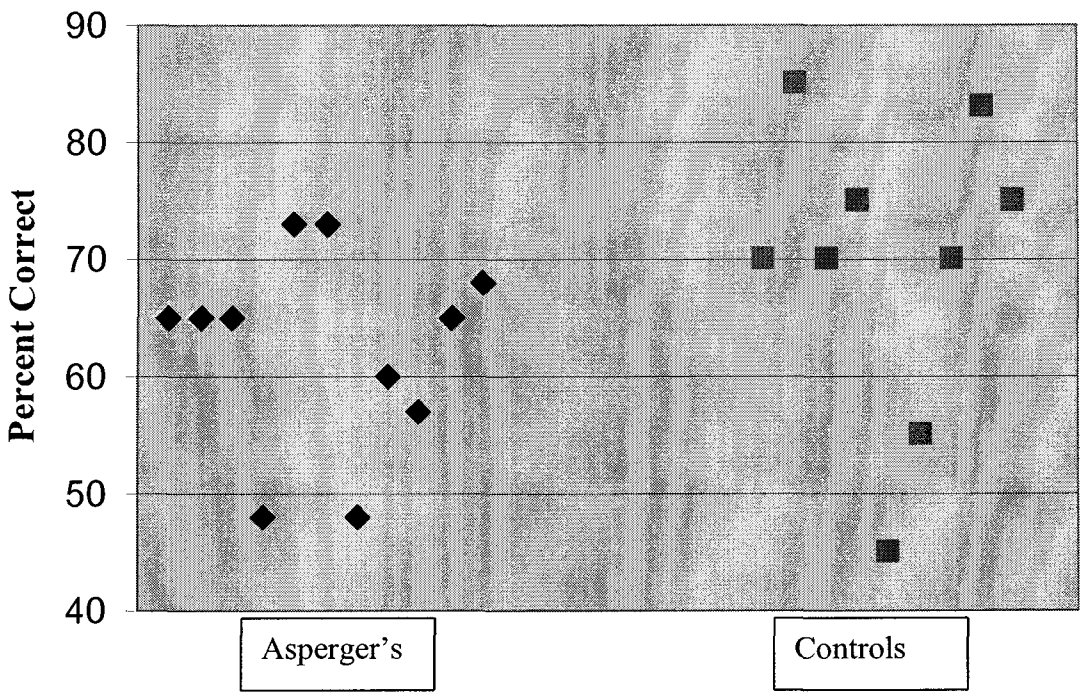

Figure 7. Participant scores on the Face Recognition task.

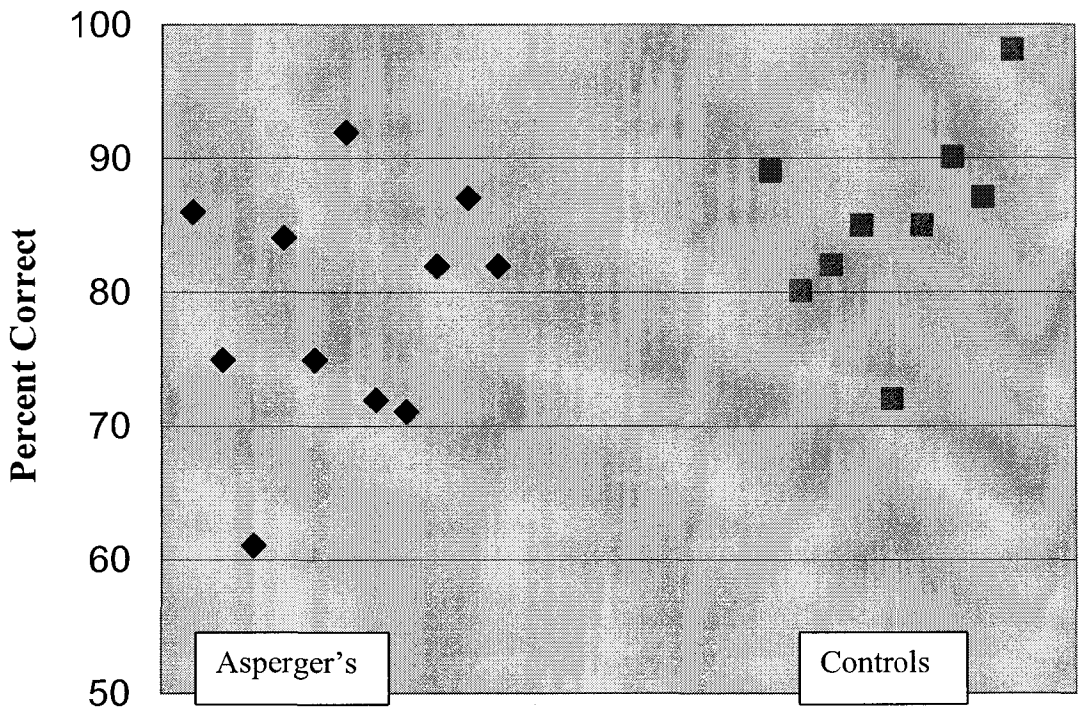

Figure 8. Participant scores on the Face Expression task.

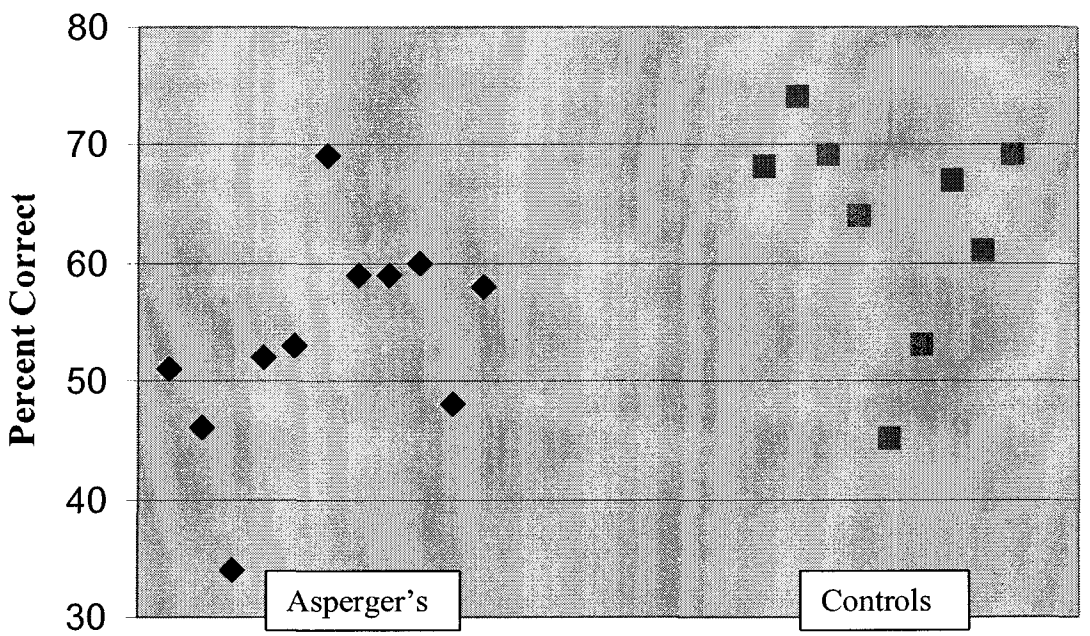

Figure 9. Participant scores on the Voice Expression task.

Correlations among Social Processing tasks and demographic variables

Pearson product-moment correlation coefficients were calculated for the seven target tasks and selected demographic variables, including age, Vocabulary T-score, Block Design T-Score, standard scores for the two scales from the Social Skills Rating Scale (Problem Scale and Social Skills), and the total score for the Behavioral Questionnaire (for the AsD group only). Three of the Social Processing tasks (Memory for Scenes, Emotion Definitions, and Social Scenes) included two distinct subscales. Thus, the most sensitive subscale from each of these tasks was included in the correlation analyses. The Memory for Scenes Recall score was selected as this appeared to be the more difficult of the two tasks and provided a wider range of scores for both groups. For the Emotion Definitions task, the Spontaneous version was more difficult than the Multiple Choice version. For the Social Scenes task, Abnormal Video Identification was selected in lieu of Total Video Identification because both the NC and AsD groups accurately identified Normal Social Scenes and inclusion of this data would not add any information to the analyses.

Intercorrelations of Social Processing Tasks. Correlations among the Social Processing tasks were analyzed separately for the two groups. The correlation matrices are presented in Table 3, with the correlations of the NC group above (to the right, outlined in light gray) the diagonal and the AsD group below (to the left) the diagonal. Given the small number of participants in this study, both significant results and trends with correlations >. 40 are highlighted below.

As shown in Table 3, the control group demonstrated an overall greater number of correlations among the target tasks than the AsD group. For the NC group, each social

Table 3

Intercorrelations for the Social Processing Tasks as a Function of Group

Measure	1	2	3	4	5	6	7
1. Face Recognition	--	.48	.85**	.93**	.25	-.36	.76*
2. Face Expression	.11	--	.54	.65	.31	-.12	.75*
3. Voice Expression	-.01[1]	.55	--	.85**	.42	-.49	.76*
4. Emotion Definitions	-.10[2]	-.27[1]	-.14[2]	--	.45	-.20	.83*
5. Memory for Scenes	.38	.28	-.03	-.04	--	.07	.57
6. Nonverbal Signals	-.44	-.12	-.28	.18	-.20	--	-.38
7. Social Scenes	.48	-.42[2]	-.26[1]	.22[1]	.76*	.01	--

Note. Intercorrelations of NC participants (n = 9) are presented above the diagonal, and intercorrelations for AsD participants (n = 11) are presented below the diagonal. [1] = significant difference between r for NC and AsD group at $p < .05$; [2] = significant difference between r for NC and AsD group at $p < .01$

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

task was significantly correlated with at least one other task in the battery, with the exceptions of Memory for Scenes and Nonverbal Signals. While the correlations of the Memory for Scenes Recall measure did not reach significance, there were moderate covariations with three tasks: Voice Expression ($r = .42$), Spontaneous Emotion Definitions ($r = .45$), and Abnormal Video Identification ($r = .57$, $p = .11$). The Abnormal Video Identification was correlated with nearly all other Social Processing tasks, as was the Emotion Definitions task. In addition, although not significant, the Face Expression task was moderately correlated with Face Recognition ($r = .48$), Voice Expression ($r = .54$), and Emotion Definitions ($r = .65$, $p = .06$).

In contrast, the correlation matrix for the AsD group indicated a relative lack of covariation among the target tasks. The only significant correlation in the AsD group was a relationship between Memory for Scenes Recall and Abnormal Video Identification ($r = .76$, $p < .05$). There was a moderate correlation between Face Recognition and Abnormal Video Identification ($r = .48$), as well as Face Expression and Voice Expression ($r = .55$). There were moderate negative correlations between Nonverbal Signals and Face Recognition ($r = -.44$) and between Face Expression and Social Scenes ($r = -.42$).

Comparison of the NC and AsD Social Processing Correlation Matrices. The Social Processing correlations were compared between the NC and AsD groups using the Fisher r to z transformation procedure. Seven of the 21 comparisons were significant; the level of significance is indicated by superscript notation in Table 3. For all comparisons that resulted in a significant group difference between correlations, the correlation of the NC group was positive and moderate to strong (range of $r = .65$ to $.93$),

while the r values for the AsD group were not indicative of positive covariation (range of r = - .42 to .22).

Correlations of Social Processing Tasks and Demographic and Behavioral measures. The Pearson product-moment correlations between the Social Processing tasks and the demographic and behavioral measures for the NC group are presented in Table 4. There was a trend level negative correlation between Vocabulary t-score and Voice Expression performance (r = -.60, p = .09). Block Design performance was moderately correlated with several tasks including Face Recognition (r = .52), Voice Expression (r = .47), Spontaneous Emotion Definition (r = .43), Memory for Scenes Recall (r = .42), and Abnormal Video Identification (r = .46), suggesting that better performance on Block Design was related to better performance on Social Processing tasks. Age was moderately correlated with Abnormal Video Identification (r = .55).

Correlations between the behavioral measures and Social Processing tasks in the NC group revealed a positive, significant correlation between the Social Skills scale and performance on Face Expressions (r = .78, p < .05). The Social Skills scale was also moderately correlated with performance on Abnormal Video Identification (r = .51) and Voice Expression (r = .44). There was also an unexpected negative relationship between the Social Skills scale of the SSRS and performance on Nonverbal Signals (r = -.69, p = .09). That is, weaker performance on Nonverbal Signals was related to better reported social abilities. Similarly, there was a positive correlation between the Nonverbal Signals task and the Problem Scale of the Social Skills Rating Scale (r = .58),

Table 4

Pearson Correlations for the Social Processing Tasks and Demographic/Behavioral Characteristic of the Normal Control Group

Social Processing Task	Vocab-t	BD-t	Age	Social Skills	Problem Scale
Face Recognition	-.29	.52	.24	.29	.10
Face Expression	-.25	.18	.38	.78*	.24
Voice Expression	-.60	.47	.11	.44	.13
Emotion Definitions	-.39	.43	.29	.27	.37
Memory for Scenes	-.16	.42	.29	-.24	.30
Nonverbal Signals	.37	-.21	.26	-.69	.58
Social Scenes	-.25	.46	.55	.51	.03

Note. Vocab-t = WASI Vocabulary Test t-score; BD-t = WASI Block Design subtest t-score; n = 9 for all correlations involving Vocab-t, BD-t, and age; n = 7 for correlations involving Social Skills scale, Problem Scale, and the AsD Behavioral Questionnaire; * = $p < .05$

indicating that a higher percent correct on Nonverbal Signals was related to higher level of reported problem behaviors.

The same correlations, with the addition of the Behavioral Questionnaire, are presented for the AsD group in Table 5. There was a moderate negative correlation between Vocabulary t-score and the Memory for Scenes task ($r = -.40$). A positive correlation between the Block Design t-score and performance on the Voice Expression task ($r = .43$) was present, as was a negative relationship between Block Design t-score and Emotion Definitions ($r = -.46$). There was also a moderate relationship between age and Memory Recall ($r = .52$).

A negative correlation was present between the Problem Scale of the SSRS and Nonverbal Signals ($r = -.46$). The Problem Scale was positively correlated with Voice Expression performance ($r = .54$) and Face Expression ($r = .40$). The Social Skills scale was negatively related to Voice Expression ($r = -.48$). Although not reported in Table 5, the total score on the Behavioral Questionnaire was negatively associated with the Social Skills scale ($r = -.62$, $p = .10$) and positively correlated with the Problem Scale of the SSRS ($r = .49$). However, the Behavioral Questionnaire was not correlated with any of the Social Processing measures.

Comparison of the NC and AsD Demographic/Behavioral and Social Processing Correlation Matrices. The correlation coefficients presented in Tables 4 & 5 (i.e., NC vs. AsD) were compared between the NC and AsD groups using the Fisher r to z transformation procedure. Although none of the 35 comparisons reached significance, five comparisons were at trend level ($p < .10$); these are identified by superscript notation in Table 5.

Table 5

Pearson Correlations for the Social Processing Tasks and Demographic/Behavioral Characteristic of the Asperger's Disorder Group

Social Processing Task	Vocab-t	BD-t	Age	Social Skills	Problem Scale	Behavior Question.
1. Face Recognition	-.08	.02	.03	.22	.18	-.28
2. Face Expression	.22	.02	.32	-.15^{+}	.40	-.10
3. Voice Expression	.25^{+}	.43	-.21	-.48	.54	-.01
4. Emotion Definitions	.02	-.46^{+}	-.15	-.34	-.34	.28
5. Memory for Scenes	-.40	-.37	.52	-.20	.39	.04
6. Nonverbal Signals	.00	.00	-.31	.39^{+}	-.46^{+}	-.23
7. Social Scenes	-.05	-.10	.15	-.19	.37	-.17

Note. Vocab-t = WASI Vocabulary Test t-score; BD-t = WASI Block Design subtest t-score; n = 11 for all correlations involving Vocab-t, BD-t, and age; n = 8 for correlations involving Social Skills scale, Problem Scale, and the AsD Behavioral Questionnaire; + = trend level difference between r for NC and AsD group at $p < .10$

Exploratory Analyses for Hypothesis Generation

Comparisons of group performance on task subscales: The overall scores for the Nonverbal Signals and Social Scenes tasks were each comprised of performance collapsed across several subscales. These subscales were designed to assess specific aspects of social processing. Thus, the first part of the exploratory analyses compared group performance on the subscales included in these two tasks. As in previous group comparisons, all reported t-tests were one-tailed and, unless otherwise reported, parametric t-tests yielded the same results as non-parametric comparisons. Mean percent correct and standard deviations for each subscale are presented in Table 6.

Subscales of Nonverbal Signals. The three types of Nonverbal Signals were first examined utilizing a Group by Subscale mixed model ANOVA. There was a statistically significant effect of group, $\underline{F}$ (1, 54) = 11.48, $p < .01$, with the NC group performing better than the AsD group overall and a main effect of subscale, $\underline{F}$ (2, 54) = 20.72, $p < .001$. There was also a Group by Subscale Interaction, F (2, 54) = 3.62, $p < .05$. Post-hoc t-tests revealed that combined performance of the two groups was significantly worse for the Complex Emotional items compared to the Non-Emotional ($p < .001$) and Simple Emotional items ($p < .01$). There was no difference between the Non-Emotional and the Simple Emotional items ($p = .10$).

Comparison of the groups on each of the three subscales indicated an unexpected difference between groups on the Non-Emotional subscale, t (18) = -2.46, $p < .05$, with the NC group outperforming the AsD group. While there was no difference between

Table 6

Group Differences for the Subscales of the Nonverbal Signals and Social Scenes tasks Between the Normal Control Group and the Asperger's Disorder Group

Subscale	NC Group M	NC Group SD	AsD Group M	AsD Group SD	t
Nonverbal Signals					
Non-Emotional	91.2	9.1	81.4	8.8	-2.46*
Simple Emotional	83.9	11.4	73.9	20.1	-1.33
Complex Emotional	76.7	11.6	48.6	20.9	-3.60**
Social Scenes					
Nonverbal	71.1	23.1	53.6	26.6	-1.56
Verbal Faux Pas	77.9	25.5	55.5	32.7	-1.70
Action Slips	73.3	18.7	58.2	26.4	-1.45

Note. **p < .01, *p < .05

groups on the Simple Emotional subscale, the NC group performed better than the AsD group on the Complex Emotional subscale, $t(18) = -3.60$, $p < .01$.

Subscales of Social Scenes. The three types of Abnormal Social Scenes were examined utilizing a Group by Subscale mixed model ANOVA. Results indicated a significant main effect of group, $F(1, 54) = 4.51$, $p < .05$. There was no main effect of subscale type and the interaction was not significant. Comparison of the groups indicated trend level differences on each of the three subscales difference: Verbal Faux Pas subscale, $t(18) = -1.70$, $p = .055$; Nonverbal subscale, $t(18) = -1.56$, $p = .07$; Action Slip subscale, $t(18) = -1.45$, $p = .08$.

Emotion Recognition: Group comparisons and error patterns for each emotion. Because previous literature suggests the possibility of independence for the recognition of specific emotions, each emotion included in the Face Expression and Voice Expression tasks was analyzed individually and error types and frequency of errors are reported for both groups. On the Face Expression task (see Table 7) the AsD and NC groups attained similar scores for anger, disgust, fear, and happy. However, the NC group outperformed the AsD group on neutral, $t(18) = -1.83$, $p < .05$, and group differences were nearly significant for stimuli depicting sadness, $t(18) = -1.62$, $p = .06$ and surprise, $t(18) = -1.71$, $p = .05$. Table 8 presents a list of the most frequent incorrect responses for both groups; all incorrect responses that occurred with greater than 5 percent frequency for either group are included in this table. These data suggest that the AsD group misidentified anger and sadness as a neutral stimulus more frequently than the NC group. Disgust also appears to have been selected more frequently by the AsD participants when angry and sad faces were presented.

Table 7

Group Differences for the Face Expression Emotions Between the Normal Control Group and the Asperger's Disorder Group

Emotion	NC Group M	NC Group SD	AsD Group M	AsD Group SD	t
Anger	77.1	15.8	65.1	24.8	-1.25
Disgust	80.9	18.0	85.9	13.7	.71
Fear	69.1	24.5	68.2	30.1	-.08
Happy	97.5	4.0	98.5	2.6	.64
Neutral	96.8	5.0	88.4	13.0	-1.82*
Sad	85.2	26.0	66.1	26.4	-1.62
Surprise	93.8	7.1	87.4	9.3	-1.71

Note. *$p < .05$

Table 8

Frequency of Incorrect Responses on the Face Expression Task

Target Response	Incorrect Responses	Frequency of Incorrect Responses NC	AsD
Anger	Disgust	9.3	17.3
	Neutral	1.8	10.7
Disgust	Anger	15.4	11.1
Fear	Surprise	24.1	18.7
	Disgust	4.3	6.1
Happy	--	--	--
Neutral	Anger	3.7	6.1
Sad	Neutral	11.1	18.8
	Disgust	3.0	9.1
Surprise	Fear	5.6	11.1

Results of the individual emotion analyses for the Voice Expression task indicated some similar patterns (see Table 9). The percent correct for anger and boredom were significantly different between groups (anger: $t(18) = -2.66$, $p < .01$; boredom: $t(18) = -2.0$, $p < .05$. The difference between group performance for the identification of sadness was at trend, $t(18) = -1.45$, $p = .08$. Table 10 presents the nearly identical pattern of errors for the two groups; all errors that occurred with more than 10 percent frequency for either group are included. While the NC group misidentified very few items depicting anger (95.1 percent correct), the AsD group most frequently confused anger with disgust. Unlike the Face Expression task, there was no option to select neutral during the Voice Expression task. Thus, it was not possible to assess how frequently the groups may have misidentified items from the Voice Expression task as neutral.

For the five emotions that were utilized in both the Face Expression and Voice Expression tasks (anger, disgust, fear, happy, sad), performance was collapsed across these two tasks. Results indicate that there was no difference between the groups with regard to the overall recognition of disgust, fear, and happiness. The NC group performed better than the AsD group when the Face Expression and Voice Expression data was combined for items depicting anger, $t(38) = -2.61$, $p < .01$, and sadness, $t(38) = -2.20$, $p < .05$.

Table 9

Group Differences for the Voice Expression Emotions Between the Normal Control Group and the Asperger's Disorder Group

Emotion	NC Group M	NC Group SD	AsD Group M	AsD Group SD	t
Anger	95.1	5.9	72.7	24.5	-2.66**
Anxiety	27.1	16.8	24.2	13.9	-.42
Boredom	92.6	7.8	79.8	17.7	-2.00*
Disgust	68.5	20.3	66.7	24.1	-.18
Excitement	46.9	27.7	33.3	28.5	-1.08
Fear	55.6	18.4	48.5	24.5	-.72
Happy	42.0	19.9	29.3	21.2	-1.37
Interest	74.1	30.9	62.6	16.0	-1.07
Pride	53.1	28.8	47.5	29.9	-.43
Sad	76.9	15.5	64.4	21.8	-1.45

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

Table 10

Frequency of Incorrect Responses on the Voice Expression Task

Target Response	Incorrect Responses	Frequency of Incorrect Responses NC	AsD
Anger	Disgust	3.7	14.2
Anxiety	Fear	29.6	33.3
	Interest	17.3	20.2
Boredom	Sadness	6.2	11.2
Disgust	Anger	19.4	19.7
Excitement	Fear	22.3	30.6
	Happy	8.6	12.2
Fear	Anxiety	24.7	19.4
	Excitement	3.7	10.2
Happy	Pride	35.8	44.5
	Excitement	13.6	13.1
Interest	Happy	11.1	11.1
Pride	Interest	22.2	21.1
	Happy	13.5	18.2
Sad	Boredom	15.7	15.9

Discussion

This study investigated several aspects of social processing in a group of individuals with AsD. By varying the complexity, modality, and type of social stimuli presented, the primary goal was to examine a new set of comparisons and survey a novel approach to assessing social processing in this disorder. In addition, the current results were expected to yield some preliminary support for one of two broad accounts (i.e., core social impairment versus associative deficit) of the underlying deficit in AsD.

Summary of Main Findings

Overall, the findings indicated group differences on several measures of social processing suggesting that the selected tests were successful in differentiating the AsD group from the comparison group. It is important to note that the AsD group also demonstrated intact performance on some measures. In particular, there were no differences between groups on a measure of estimated verbal and performance IQ, indicating intact intellectual capacity. In addition, the performance of the AsD group did not differ from that of the NC group on the Emotions Definitions task, indicating intact semantic knowledge of emotion words. The pattern of performance in the AsD group suggests deficits specific to certain aspects of social processing, rather than an overarching deficit for all types of cognitive or social tasks. Thus, the subset of social tasks included in this study appears to have been successful in measuring the intended functional domain. Given the small sample size, follow-up studies will be important in order to determine the psychometric properties of these tasks and their potential utility for clinical and research purposes.

The fact that large group differences were detected on several tests and subscales despite the small number of subjects is promising with regard to the sensitivity of these measures. However, given that many group comparisons were completed, the likelihood of Type I errors must be considered. The possibility that some of the current findings will not be replicated in future studies is certainly acknowledged and anticipated. Investigations of these tasks in potentially larger groups will be important in determining which of the specific findings represent true group differences. It is expected that several findings are indicative of important areas of social processing impairment and will yield interesting lines of future research.

In addition to group differences on specific tasks, the relationship among the tasks differed for the two groups. Although performance on individual subtests appeared to conform to a certain level of organization in the normal comparison group, an indication of task relatedness was completely lacking in the AsD group. This type of disjointed pattern is suggestive of pathology and supports the notion that the functional domain assessed by this set of tasks is a less integrated system in the AsD group. Thus, the group differences on specific subtests, in combination with the lack of relationships among the subtests, offer strong support for a deficit in the domain of social processing in the AsD group.

The general findings are consistent with recent literature that has also focused on fundamental abilities in AsD and how these may relate to the social symptoms that characterize the disorder. Other studies utilizing videotaped social interactions (Channon et al., 2001; Heavey et al., 2000) have reported similar impairments in processing specific aspects of such complex social information. In addition, Klin (2000) demonstrated a lack

of sensitivity to the social elements of ambiguous visual stimuli in AsD and HFA, and increased reporting of irrelevant and nonpertinent information such as unrelated stories and attention to aspects of the stimuli that were not relevant to the task demands. These studies represent a recent shift in methodological approaches to AsD and, similar to the current study, suggest that individuals with AsD have difficulty processing various types of social information.

This discussion will take a closer look at the most noteworthy findings of the current study and consider the potential role of these deficits as core features of this disorder. In addition unexpected results are discussed. The combination of confirmatory results and lack of positive findings on some subtests offer a variety of interesting directions for future research. Possible future directions will be discussed as they pertain to specific findings of the present study.

Relationships Among Social Processing Tasks. One of the main findings suggests that the social deficits in AsD may be due to a lack of integration among the components or subprocesses important to understanding social interaction. The pattern of correlations among the social tasks indicate that in the NC group the abilities measured in this study are associated in a rather systematic manner, suggesting the presence of a single, organized function. In the normally developing adolescents and young adults, there appears to be a common thread or perhaps an underlying factor within this set of social processing tasks.

In striking contrast to the relationships among tasks in the NC group, there was a clear lack of association among the social processing tasks in the AsD group. In particular, performance on Social Scenes was correlated with performance on several

other tasks for the control group, while the results revealed no such relationships in the AsD group. The Social Scenes task, which presented two or more actors engaged in a social interaction, was intended to assess a complex level of social processing and was expected to require the integration of some basic social processing abilities (or subprocesses) measured separately in the other more "elementary" or "social-perceptual" tasks (i.e., face recognition, voice expression, etc.). This methodological assumption appears to be supported by the NC performance. Although the abilities required for intact performance of Face Expression, Voice Expression, and Emotion Definitions appear to share cognitive features with or contribute to the processing of the Social Scenes for the NC group, these elements were not related to performance on this complex social judgment task for the AsD participants. The lack of relationships among the Social Processing tasks for the AsD group suggests that they applied a fragmented or disconnected approach to processing the stimuli, rather than tapping a coherent set of social-cognitive abilities.

Similarly, the Emotion Definitions task was strongly associated with Face Recognition, Face Expression, Voice Expression, and Social Scenes for the NC group. Again, this differed dramatically from the lack of correlation between the Emotion Definition task and any of the other Social Processing tasks. This result is especially noteworthy in view of the fact that the level of accuracy of the AsD group did not differ from that of the NC group on the Emotion Definitions task. Although the AsD subjects were knowledgeable about the meanings of emotion words, this knowledge was unrelated to the processing of other social-emotional information. This result suggests that some semantic information relevant to social function is intact in AsD and that this is in the

context of a disrupted social-cognitive system. This is consistent with the notion that individuals with AsD are able to learn the formal rules of social interaction, but have difficulty applying this knowledge in a useful way.

Overall, the differences in correlation matrices of the AsD and NC groups suggest two distinct approaches to the Social Processing tasks. One interpretation of these results is that the performance of the AsD represents a less integrated social cognitive system secondary to developmental impairments in processing and possibly perceiving elementary and complex stimuli. However, other explanations are certainly plausible. One possibility is that factors other than poor social processing may be driving the lack of relationships in the AsD group. Factors such as attention and motivation were not measured, but could potentially play important roles in performance on the Social Processing tasks. The relationships present in the NC group suggest that the approach to the tasks was highly consistent and therefore the correlational analyses were not confounded by variability in performance. However, it is possible that the interest and attention of the individuals in the AsD group was not constant across tasks and that variable performance is responsible for the group differences in the correlation matrices. Although attempts were made to keep the testing sessions interesting and as brief as necessary, it is not possible to determine the role of motivation and attention in the AsD performance. Furthermore, outlier data would greatly affect the correlational data in this small sample size. Scatter plots of the AsD data were examined and an outlier was present on a few tasks; however, the remainder of the data (i.e., the other 10 data points) did not conform to a linear relationship.

Although the underlying structure of social processing in AsD is speculative at present, the current data raise interesting possibilities about the relationships among the abilities required to process specific types of social stimuli. The findings highlight the nature of the relationships among these tasks as an important issue warranting further investigation. Additional work investigating such relationships will be important, not only for improving our understanding of AsD but, in expanding knowledge regarding the components and structure of social processing in general.

Memory Functioning. A second compelling finding was the sizeable deficit in the AsD group on a measure of memory for social information. While this was not a primary focus of the current project, the results are an important contribution of this study. At the onset of this project only one study had explored memory in AsD (Bowler et al., 1997). Although this study indicated that a group of individuals with AsD did not utilize semantic context to aid in free recall, the findings did not speak to memory for social information and the authors did conjecture with regard to memory for social stimuli in this group. In the present study, the Memory for Social Scenes task was included as an exploratory measure to investigate the possibility that impaired recall of social information may be a component of the social processing impairment in AsD. Results revealed that the AsD group was impaired, relative to the comparison group, when asked to identify a subset of the Social Scenes based on the presentation of an abbreviated version of the previously viewed scenes.

While both groups recognized the scenes with a fairly high level of accuracy, it is important to keep in mind that there was only one scene in the Recognition version of this task that was not presented initially (i.e., only one foil). That is, if each subject indicated

that s/he had viewed every scene, the recognition scores would have yielded a high level of accuracy. Although the Recognition score was sufficient for ruling out false negative errors, it did not address the possibility of a possible false positive bias. With regard to recall, the AsD group demonstrated impairment when asked to identify a scene by giving a brief description that accurately differentiated a scene from the others. Of the scenes that the NC group recognized, they were able to accurately identify 88 percent of the scenes. In contrast, the AsD group accurately described only 53 percent of the scenes that were initially recognized. This suggests that the Recognition results for the AsD group may have been inflated by a 'yes-saying' bias. Alternatively, the scenes may have been familiar to the AsD participants, but the salient details required to differentiate the scenes were not available.

Since the implementation of the current study, additional work by Bowler and colleagues (Bowler, Gardiner, & Grice, 2000; Bowler, Gardiner, Grice et al., 2000) demonstrated a pattern of performance suggestive of strong semantic memory and relatively weak episodic memory in individuals with AsD. The authors suggest a potential relationship between the problematic social functioning in this disorder and impaired episodic memory. In addition, less effective elaborative encoding and less effective source monitoring were also described as deficit areas in the memory functioning of AsD. The current study is the first to investigate recall of more complex and socially laden information and the results clearly indicate a deficit in recalling this type of stimuli. Accurate recall of the details of these scenes relies heavily on episodic memory, as well as the ability to recall the source of the information.

Given that learning and memory play an important role in social development, investigations of the nature of the memory deficit in AsD will be an important direction for future research. Accurate storage and retrieval of past social interactions is important in order to compare current interactions with previous encounters. Bowler et al. (2000) argued that any impairment in remembering (i.e., episodic memory) "has rather important general implications because of the vital role played by autonoetic awareness for goal-directed behavior, and for future actions that are planned on the basis of previous personal experiences, remembered as such" (p. 301). If previous social interactions are incompletely stored, stored inaccurately, or difficult to retrieve the impact on social functioning could be profound.

The current results, in conjunction with the work of Bowler and colleagues, are intriguing in the context of a current model of memory, the Multiple Trace Theory (MTT, Nadel, Samsonovich, Ryan, & Moscovitch, 2000). In contrast to standard consolidation theories of memory, MTT proposes that the hippocampal complex is necessary for both the storage and retrieval of episodic memories. Semantic memories, on the other hand, can eventually be recalled independent of the hippocampal complex. In this model, each episodic memory forms one initial trace, which can decay over time or can be replicated to produce additional traces. Investigations of amnesic patients and normal individuals appear to support this theory, particularly when methods involving autobiographical memory are employed. Although the hippocampus is not discussed frequently in the AsD literature, abnormalities in this structure, as well as the entorhinal cortex have been reported in autism (Bauman & Kemper, 1985). The amygdala, of course, is proposed to be an important structure in both AsD and autism and is purported to have an important

role in social-emotional memory. The amygdala has not yet been discussed within the MTT framework. It is possible that temporal and limbic abnormalities underlie the episodic memory deficits in AsD. Future studies of memory in AsD will serve to elucidate the possible dissociation between episodic and semantic memory in this population as it relates to MTT and other theories of memory.

Although results of the current memory task are preliminary, they offer some interesting possibilities for future research. Given the exploratory nature of this task it was not methodologically equipped to thoroughly explore memory functioning in AsD. One obvious weakness of the design was the lack of foils included in the recognition task. As suggested, the high level of accuracy on the Recognition version of the current memory task may represent a yes-saying bias rather than intact recognition of the scenes. Increasing the number of foils, as well as varying the types of foils would allow for further investigation of recognition memory processes in AsD. For example, one could create scenes that are nearly identical to the originals in content, but with different actors or the same actors with reversed roles. In addition, foils could present the same setting and content, while either adding an abnormal aspect to a normal scene or removing the abnormal aspect from a previously abnormal scene. These foil variations would allow for a more detailed investigation of the aspects of the scenes that the AsD participants are able encode and retrieve. In addition, decreasing the number of scenes presented and adding immediate recognition and recall conditions would offer more information about an individual's ability to attend to and initially encode complex social stimuli. It will also be important to examine performance on other types of memory tasks (i.e., standardized verbal and visual memory tests), in order to compare the ability to recall social

information with the ability to recall other types of information. In particular, comparisons of episodic and semantic memory, using tools such as autobiographical memory measures will be valuable.

Finally, the current methodology could be expanded to investigate 'depth of processing' with regard to memory for social information in individuals with AsD. The same type of memory task could be employed after allowing participants to passively view the scenes. That is, the participants would not be asked to judge the scene in any way, but simply instructed to view it. Explicit episodic learning could also be assessed by asking the participants to learn and remember specific details of each scene. Given the paucity of research focused on memory function in AsD and the potential relationship between a deficit in episodic memory and the social impairment in this disorder, further investigations of memory abilities in this group are clearly warranted.

Emotion Recognition. A third noteworthy finding is the pattern of performance demonstrated by the AsD group on tasks measuring emotion recognition. The results are suggestive of difficulty processing specific emotions; anger and sadness were particularly difficult for this group relative to the other 'basic' emotions, including disgust, fear, happiness, and surprise. This finding is intriguing within the context of recent findings indicating specific emotion processing deficits in other groups with neurobiological deficits (i.e., Huntington's disease, amygdala lesioned patients, Obsessive-Compulsive Disorder). Recent studies of recognition and processing of specific emotions suggest potentially separable neural mechanisms in the recognition of at least two emotions: fear and disgust (see review, Calder et al., 2001). In addition, a recent study (Whalen et al.,

2001) investigating fMRI activation in the amygdala of healthy normal subjects suggests that anger and fear may be processed independently within this structure.

This interesting set of findings prompted the current exploratory analysis of group performance on each of the emotions depicted in the Face Expression and Voice Expression subtests. For the Face Expression task, the AsD group demonstrated weak performance, relative to the comparison group, for items depicting sad and surprised faces relative to the control subjects. For the Voice Expression task, recognition of anger and boredom were impaired. When results for five basic emotions were collapsed across these two modalities, the AsD group demonstrated difficulty recognizing anger and sadness were present, in contrast to intact identification of disgust, fear, and happiness. These results, although preliminary, offer further support for separable processing of specific emotional stimuli.

Using an arbitrary cutoff of 70 percent correct, individual patterns of performance on the Facial Expression task indicated that three participants in the AsD group did not demonstrate difficulty with sadness or anger, while the other eight subjects performed poorly on at least one of these emotions. Four individuals in the AsD group had difficulty with both emotions. In contrast, two NC participants had difficulty with anger and one had difficulty with sadness; no member of the NC group demonstrated impairment on both of these emotions.

While neuroimaging has not revealed a consistent pattern of structural abnormalities in patients with AsD (Lincoln, Courchesne, Allen, Hanson, & Ene, 1998), further studies of emotion recognition may offer some clues about the neurobiology of AsD. In contrast to patients with Huntington's Disease (HD), who consistently

demonstrate impairment only in the recognition of disgust (Halligan, 1998; Sprengelmeyer et al., 1996), the AsD participants demonstrated intact recognition of disgust in both faces and voices. The finding of impaired disgust recognition has also been reported in individuals that are gene-positive and presymptomatic for HD, (Gray et al., 1997), suggesting that the neuroanatomical substrate involved in the recognition of disgust is affected very early in the course of the disease process. Neuroanatomical studies of presymptomatic gene-positive HD (Gomez-Tortusa et al., 2001) indicate that the tail of the caudate is the area where the earliest structural changes are detected. Thus, it is often assumed that this area and/or the circuitry related to this region are involved in the recognition of disgust. If this is true, the discrepancy between AsD and HD groups in patterns of emotion recognition performance may suggest that the neuroanatomical region affected in early stage HD is intact in individuals with AsD. The differences in emotion recognition patterns in these two groups is particularly relevant in light of recent work implicating a role of fronto-striatal pathways in AsD (McAlonan et al., 2002) and autism (Rinehart, Bradshaw, Brereton, & Tonge, 2002).

Furthermore, patients with damage to the amygdala have been reported to have difficulty with the recognition of fear, but intact recognition of other emotions (Calder et al., 2001). Human and non-human primate research indicates reduced levels of aggression and fear in animals with bilateral amygdala lesions (Brothers, 1997). Although fear recognition was not impaired in the AsD group as a whole, there is some indication that recognition deficits in anger and sadness were accompanied by deficits in recognizing fear. For the combined face and voice results, 4 individuals with AsD were impaired (i.e., < 70 percent correct) on all three emotions and an additional participant

was impaired on anger and fear. While NC subjects had more difficulty with fear than any other emotion (four performed below 70 percent correct), the subjects that had difficulty with fear did not demonstrate deficits in the recognition of other emotions. None of the AsD participants showed a fear recognition deficit in isolation.

As presented in the introduction, neuroanatomical models of autism and Asperger's Disorder, as well as discussions of neurocircuitry involved in social cognition, argue strongly for a central role of the amygdala (Baron-Cohen & Ring, 1994; Baron-Cohen et al., 2000; Brothers, 1997). While the lack of a distinct impairment in the recognition of fear may argue against extensive disruption of the amygdala in AsD, the possibility of overlapping difficulty with the recognition of fear, anger, and sadness suggests that a disruption in the amygdalar circuitry could account for the combination of these deficits. Although the amygdala may be specialized to respond to highly salient emotions including fear and anger, the expertise of this system may be less sophisticated in AsD. A possible explanation of the pattern of performance in AsD is that the amygdalar system in individuals with this disorder is less able to distinguish between emotions with negative valence and may therefore require more information to reach a particular threshold for recognition.

Another way to conceptualize the current emotion results is to consider the nature of each of the "basic" emotions included in the voice and face expression tasks. From an evolutionary perspective, recognition of fear and disgust is critical for survival. The presence of these expressions on the face of another human indicates that danger is present and that immediate preparation of a protective response is required. The ability to recognize fear and disgust were, in general, intact in this AsD group. In contrast,

sadness and anger might be considered 'social' emotions in that they almost always occur in the context of a relationship or interaction with another person. One might imagine that expertise in the recognition of anger and sadness is necessitated by complex social structure and highly developed social interaction. Recognition of these emotions is critical for maintaining relationships and at the core of relating to someone in an empathic manner. The relative deficit in recognizing these two emotions is notable in light of problems with empathy in individuals with AsD. The lack of empathy often described by family members and clinicians may be related to difficulty recognizing the expression of these important 'social' emotions.

The error patterns for the Face Expression task also offer some potentially useful information. As a group, the AsD participants misidentified sadness and anger as a neutral expression relatively more frequently than the NC group. This suggests that, at times, individuals with AsD fail to detect any emotion in a face when sadness or anger is demonstrated. Unfortunately, the Voice Expression task did not include a Neutral response option. Instead, the participants selected from a group of ten emotion terms. The AsD group demonstrated similar error patterns compared to the NC participants, but demonstrated increased error rates. The most frequent error patterns on the Voice Expression task for both groups were selecting disgust when anger was presented and boredom when sadness was the target. Follow-up studies of both face and voice recognition should include a neutral response option in order to determine the frequency of this response.

A potentially valuable future direction will involve the combination of functional neuroimaging with investigations of the processing of specific emotions in AsD.

Although structural neuroimaging has not been informative in this group, some functional neuroimaging work has indicated potential functional impairments including different patterns of activation in AsD and HFA compared to normal control subjects during face recognition and processing of emotion faces (Critchley et al., 2000; Schultz, Gauthier et al., 2000). Before proceeding in this direction, it will be necessary to replicate the results of the present study to determine if deficits in the recognition of anger and sadness and intact recognition of the other basic emotions are reliable and generalizable within AsD. If the deficits in recognition of specific emotions are replicable in other AsD groups, moving these studies into the functional neuroimaging domain may offer additional information regarding the relative activation of brain regions hypothesized to contribute to processing of emotion stimuli. Functional neuroimaging studies involving both passive and active processing of face and voice emotions may reveal the involvement of specific neuroanatomical substrates in AsD.

Unexpected Findings

Although the results of this study generally indicated expected differences between the AsD and NC groups on the Social Processing tasks, a few comparisons yielded unexpected differences, while others were contrary to predictions. Unexpected findings on two subscale comparisons were present, both suggesting deficits not discussed in previous AsD literature. The first unexpected difference was on the Non-Emotional subscale of the Nonverbal Signals task. This task was designed to measure participants' understanding of nonverbal gestures and body language by presenting a brief videotaped gesture depicted by an actor. Three subscales were included in order to assess the role of emotional content, as well as complexity of the intended message. The

AsD group unexpectedly performed poorly on the subscale containing Non-Emotional items, suggesting a general deficit in understanding gestures, regardless of the presence or absence of emotional content.

The fact that even simple gestures can be comprised of subtle messages was exemplified by the difference in group performance on the Non-Emotional item depicting an actor waving "goodbye". Although hello and goodbye are similar, the actor's intended meaning was goodbye; this is what he was instructed to depict and it was the message he intended to give the viewer. It is striking that 8 of the 9 normal controls correctly indicated that the actor demonstrated goodbye, while 7 of the 11 AsD subjects incorrectly indicated that the gesture meant "hello". Although the subtle body language differentiating hello and goodbye is complex, it is obvious that the actor's intention was clear to the NC group, while not at all clear to the AsD group. The stimuli for this item consisted of a man standing alone, looking directly at the camera with a slightly positive facial expression. He lifted his arm so that his hand was at the height of his head and then began to wave. The waving movement was a slight motion from side to side with his hand, approximately 6 times. The video clip was about three seconds in duration. It is remarkable that even such a simple gesture caused difficulty for the AsD group, while eliciting an automatic correct response from the NC participants.

Also of interest was the lack of correlation between the Nonverbal Signals task and any of the other tasks in the Social Processing battery. For the NC group, this was the only subtest that was not correlated with any other task. This result suggests that this subtest may represent a distinct type of stimuli or that it involves a separate cognitive process. Given that the AsD group demonstrated a rather large overall impairment on

this task and that subscale comparisons indicated impairment for this group on the Non-Emotional and Complex Emotional items, further investigations of this task seem warranted. Intuitively, it would seem that recognition of facial emotion would play a strong role in the ability to accurately interpret Complex Emotional items. However, the lack of correlation between the Facial Expression task and the Nonverbal Signals task in the NC group suggests that this may not be the case and that the approach to Nonverbal Signals may involve other processes.

Furthermore, in the NC group, worse performance on the Nonverbal Signals task was related to better Social Skills and to fewer problem behaviors. This counterintuitive finding was in contrast to the positive relationship between performance on this task and better reported social skills in the AsD group. It is difficult to explain this group difference, other than to notice that it is consistent with the other aspects of the data which suggest that the Nonverbal Signals task measures an ability that is distinct from those measured by the other tasks.

The intent of including the Nonverbal Signals task in the battery was to investigate the ability to comprehend complex nonverbal aspects of social communication, in comparison to the assumedly more complex, multimodal input comprising the Social Scenes. However, the Nonverbal Signals appear to be unique in some way and perhaps not the same type of nonverbal stimuli that comprised the Social Scenes. The stimuli included in this task could be considered a specific type of gesture sometimes referred to as Emblems or symbolic gestures. According to Bitti and Poggi (1991) these are distinct from other types of gestures because they are "intentionally emitted signals with a specific meaning that can be directly translated into words" (p.

434). In contrast, other types of gestures serve to enhance the meaning of social communication and cannot be translated except in the context of the global interaction. Thus, the stimuli (or at least many of them) presented in this task may be representative of a specific category of gestures and this may help to explain why this task was not correlated with other Social Processing tasks.

Another unexpected finding was the impaired performance of the AsD group on the Action Slips subscale of the Social Scenes task. Recall that the items included in this subscale were designed to serve as non-social control items for the abnormal social (verbal faux pas and nonverbal) items. The Action Slips consisted of errors such as handing someone the wrong item or leaving something of importance behind, in contrast to the social nature of the errors in the abnormal verbal and non-verbal scenes. Instead of performing better on the Action Slips subscale, the AsD group demonstrated the same level of performance on all three abnormal subscales (approximately 55 percent correct).

Although the raw score difference between groups was smallest on the Action Slips, the fact that the AsD group demonstrated difficulty on these items suggests that their poor performance on the Social Scenes task was not simply related to difficulty recognizing verbal and nonverbal abnormalities in social interaction. Although it is not possible to determine the specific aspects of cognitive processing that contributed to poor performance on all three abnormal scene subtypes, it may be that the social nature of the scenes led to difficulty processing the relevant information. In addition, the complexity of the scenes may have impeded processing of all Social Scenes. Whereas the normal comparison individuals appeared to easily and quickly detect the intended "abnormal" social or nonsocial behavior, the AsD participants demonstrated a more purposeful

approach to deciding what was relevant in each scene and what was not. Qualitative observations during testing indicated that the AsD subjects processed the video scenes in a more detailed manner and were generally slower to respond. While detecting abnormality was relatively automatic in the NC group, there appeared to be more 'effortful' problem solving taking place for the AsD participants.

For example, one AsD participant performed very well on the social scenes task with regard to overall percent correct (94 percent correct for identification of Abnormal Scenes), but he deliberated at length on many items and considered aloud many false positive responses before deciding on the correct answer. In total, he also asked for more than 70 rewinds while viewing the scenes; this was highly atypical behavior relative to all other subjects. His process of working through all of the possibilities before finally reaching a correct conclusion was very telling with regard to the ineffectiveness of his daily social interactions. Successful interaction with others requires rapid interpretations of behavior and adjustment of one's output according to the rapidly changing social environment. The examiners noted that other AsD subjects also suggested a variety of possible problems with the scenes before deciding on a final response. At times, some participants even stated the correct response as one possibility, but then selected an alternative response as the final answer. The NC participants rarely suggested multiple responses, but instead appeared to quickly and efficiently detect the intended abnormality.

Implications about the underlying deficit in AsD

As presented in the introduction, there are two broad classes of explanations for social deficits in AsD and autism, those that suggest an Associative Deficit underlies the

disorder and those that hypothesize a Primary Social Deficit. The following sections consider the current data with regard to the proposed deficits that have been discussed in previous literature.

Is there support for an Associative Deficit(s)? A possible explanation for the poor performance of the AsD group on these social processing tasks is that the difficulty was the result of poor attention. According to parent reports, the AsD group had a high rate of attention problems; seven parents of AsD participants returned the Developmental History Form and 6 indicated multiple attention problems. In contrast, none of the 5 parents returning these forms for the NC participants reported attention problems. This is consistent with AsD literature indicating that Attention Deficit-Hyperactivity Disorder (ADHD) is a frequently occurring comorbid disorder (Klin & Volkmar, 1997). Attention problems can certainly contribute to or exaggerate deficits in various cognitive domains, so it seems possible that these difficulties also influence social processing. Individuals with attention problems may have increased difficulty directing attention to relevant aspects of social stimuli.

An attentional explanation of the social processing deficits reported in this study would be consistent with an Associative deficit model of Asperger's Disorder. One possible hypothesis is that impaired attention disrupted the development of age-appropriate social abilities. Alternatively, one could hypothesize that social processing abilities are present but that attention problems interfere with the application of these skills. Further explorations of the role of attention in detecting socially salient information should include individuals with ADHD in the absence of autism or AsD. Individuals with ADHD reportedly demonstrate difficulties within the social realm, but

the pattern of social impairment in this disorder is not yet characterized. There is increasing evidence for a link between social impairment and deficits in attention (Cadesky et al., 2000; Clark et al., 1999; Rapport et al., 2002; Singh et al., 1998), indicating the need to further investigate this potential relationship. While it is often assumed that the social difficulties accompanying ADHD are secondary to impulsivity and failure to inhibit inappropriate behavior, recent work suggests that social impairment in ADHD may be more complicated.

Comparison of groups with AsD and ADHD on social processing tasks would better characterize and differentiate the social impairments in these disorders as well as examine the role of specific aspects of attention problems in perceiving and interpreting social stimuli. This comparison would assist in determining the specificity of social tasks with regard to assessing social deficits versus other cognitive impairments. Importantly, examining the relationships among the social tasks in the ADHD group would shed some light on the issue of whether the current findings are specific to AsD.

Another possible Associative Deficit explanation is the presence of atypical patterns of global–local processing in AsD. This type of abnormal processing may be relevant to performance on the current social processing tasks in general and, in particular, the Social Scenes task. It is possible that intact performance on the Social Scenes task requires the ability to preferentially attend to global information, while secondarily picking out the deviant details. Focusing on the 'big picture', while ignoring irrelevant details would be useful for detecting when a detail is inconsistent with the global information. Individuals in the AsD group may have had difficulty ignoring

irrelevant details, making it difficult to process the global information and efficiently detect abnormal target features.

Recall that observations indicated that AsD subjects frequently considered several incorrect features of the scenes and seemed to be overly focused on a variety of irrelevant details. This pattern of responses suggests that local processing may have interfered with processing the scene as a whole. In addition to affecting the processing of the scenes initially, a lack of global precedence would also impact the ability to recall the scene at a later time (i.e., Memory for Scenes). Future inclusion of tasks examining both global – local processing and social processing in the same battery may offer further insight into the potential role of atypical perceptual processing in social functioning.

Is there support for a Primary Social Deficit? Although deficits in attention or local-global processing may affect social processing abilities, the current results offer strong support for the presence of a Primary Social Deficit in AsD. The difference in the relationships among tasks between the AsD and NC groups is the fundamental evidence in favor of this argument. As discussed above, the presence of several correlations between the social tasks in the NC group suggests an overlap in the cognitive abilities involved in processing the various types of information. Simple and complex tasks were related, as were tasks presenting stimuli in distinct modalities. Despite varied task demands strong relationships among tasks were evident, suggesting a fundamental link between tasks. The pattern of relationships is beyond what would be expected if specific cognitive processes, such as intact attention or global-local processing, were responsible for intact performance. In addition, because the AsD and NC groups were matched for general cognitive ability (i.e. estimated IQ), there is no reason to believe that performance

on the social tasks was related to overall intellectual ability. Furthermore, the differences between groups for the correlations of Social Processing tasks with Vocabulary, Block Design, and age were minimal, suggesting that cognitive abilities and developmental level did not play a role in the differences between groups.

The AsD group did not demonstrate evidence of a cohesive ability, or set of abilities, that may have been applied to the social tasks. Instead, task performance in the AsD group suggested unique processing for each task. Even when performance on a task was not impaired (Emotion Definitions) or relatively intact (Face Recognition), there was no overlap with other social tasks. Thus, the processing of the social stimuli, even when quantitatively normal, is likely qualitatively different from that which occurs in normal individuals. These observations are consistent with the notion that a Primary Social Deficit underlies the social processing impairment in AsD. Although further work is necessary to determine the relative role of a Primary Social Deficit, as well as the influence of possible Associative Deficits, I argue that the current results offer support for a Primary Social Deficit as the core underlying impairment in AsD.

Social Information Processing Model

Neurobiological models of autism and AsD were presented earlier in this paper. Although the proposed neuroanatomical structures and networks underlying these disorders are frequently discussed in current literature (Baron-Cohen & Ring, 1994; Baron-Cohen et al., 2000; Brothers, 1996), models representing neuropsychological and cognitive explanations are limited. Thus, it is difficult to present methodology or interpretations of results within a meaningful structure or social-cognitive model. Examination of the relationships of various social and non-social cognitive abilities and

the role of specific cognitive abilities in the processing of social information is challenging without the guidance of a model.

This section presents a model from the developmental clinical literature suggesting this framework as a useful starting point for organizing and conceptualizing the social deficits in AsD. Crick and Dodge (1994) proposed a Social Information Processing Model (see Figure 10) for the purpose of understanding children's social adjustment. This model divides social cognition into several stages including encoding, interpretation, and behavioral enactment. A central role is occupied by a database that includes social knowledge, memory stores, social schemas, and acquired rules. The information in this database is engaged at all stages and thus, affects the way in which social information is processed at all points in the model.

The model assumes that children "come to a social situation with a set of biologically limited capabilities and a database of memories of past experiences" (Crick & Dodge, 1994, p. 76). The input to the system is an array of cues and the final behavioral output depends on several processes along the way. Although the essential steps are proposed to follow a logical sequence, the model represents the rapid on-line processing that takes place in most social situations. In general, processing at each stage is completed automatically without conscious awareness of the complexity involved. In addition, different processes are thought to occur simultaneously in response to the constant changes in the social environment.

Until recently, the final stage of processing, Behavioral Enactment, has been the emphasis of research in AsD. Although there can be no argument that this final stage is impaired in this disorder, deficits at earlier stages are likely of greater import in the quest

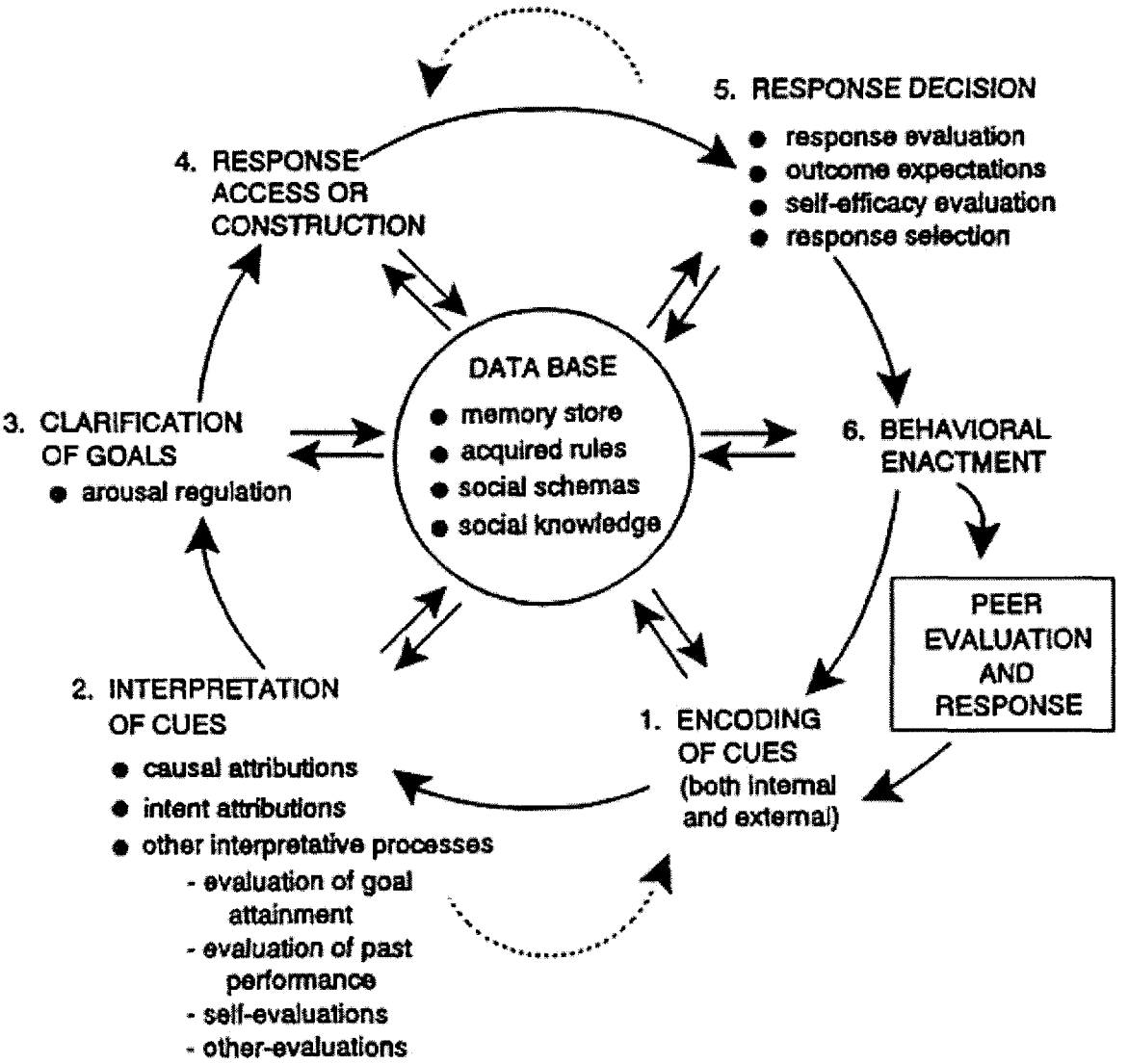

Figure 10. Social Information Processing Model (Crick & Dodge, 1994)

to understand the underlying deficit. This model highlights the various stages in the social information processing system that may contribute to observed impairment in social behavior. The results of the current study are argued to be consistent with impairment in the early stages of social information processing, including Encoding of Cues and Interpretation of Cues. However, it is difficult to distinguish between deficits due to encoding problems and those resulting from interpretation impairments. For example, impaired performance of the AsD group on the Social Scenes could indicate problems encoding or detecting the most relevant aspects of the scenes. Alternatively, encoding may have been intact, but participants had difficulty interpreting the errors as atypical behavior. Finally, problems at either of these stages may have been influenced by problems with the database (i.e., application of previous social information), as this appears to be essential in guiding the encoding and interpretation processes.

According to the model, "it is proposed that a mental representation of past events is stored in long-term memory. Later, this memory is integrated with other memories into a general mental structure that guides the processing of future social cues." (Crick & Dodge, 1994, page 78). Complex information such as schemata and scripts, as well as working models of social relationships are important aspects of the database. Notice that the database has bi-directional connections with each stage of the model, indicating that development of the social database is affected by the encoding and interpretation stages of this model. The concept of the database in this model is consistent with previous work indicating the central role of higher order scripts and schemas in the organization of memory content (Bransford & Franks, 1971). The poor performance by the AsD group on the Memory for Scenes task may be related to difficulty encoding the social scenes

within a meaningful script or schema, thus leading to poor recall of the scenes. The development and integration of social scripts and schemas in AsD may be impeded by various social processing impairments which are constant throughout the lifespan. Although this study is only a first glimpse into this possibility, this question could be addressed more systematically in future work. An investigation of the relationship between schema processing and interpersonal dysfunction in schizophrenia (Corrigan, Wallace, & Green, 1992) demonstrated schema deficits in the patient group suggesting support for this line of research in AsD.

It is important to consider how the "biologically limited capabilities" that impact the model in normal individuals may differ for individuals with AsD. Neurobiological deficits in AsD, such as problems detecting the emotional and social salience of stimuli (Klin, 2000) would likely interfere with encoding and interpretation. Encoding deficits would then affect the formation of schemata, subsequently leading to difficulty in situations where these previous experiences would be important at a later time. A deficit in the database is consistent with anectdotal descriptions of individuals diagnosed with AsD and HFA, such as Temple Grandin (Sacks, 1995). The experiences reported by individuals with these disorders suggest a lack of integration of previous social interactions and difficulty forming representations that are necessary for guiding future behavior. Instead of automatically producing behavioral responses according to appropriate schemas and social knowledge individuals with AsD and HFA report a process of consulting explicitly learned rules that may lead to generalizations and behaviors that are not necessarily appropriate for the situation.

While the current findings suggest a deficit in memory for social information, the details of this problem require further definition. If, as Bowler and colleagues (Bowler, Gardiner, & Grice, 2000; Bowler, Gardiner, Grice et al., 2000) hypothesized, individuals with AsD have impairment in episodic memory is correct, this would greatly impede the formation of a useful database as conceptualized in this model. Based on work by Nadel et al. (2000) autobiographical memory appears to be a sensitive measure of episodic memory functioning. Applying methods previously used to investigate autobiographical and semantic memory in amnesia to studies of AsD may clarify questions about the memory capabilities in individuals with this disorder. In addition, future explorations of scripts and social schemas in AsD may be useful in understanding the role of memory in social functioning in both normal subjects and those diagnosed with AsD.

While Crick and Dodge (1994) did not make suggestions regarding the neuroanatomical circuitry that might underlie specific aspects of the model, it is possible to consider how this model may map onto the neuroanatomical models that have been put forth in the social cognition literature. At the encoding level, there would be an important role of social attention, as well as more general attention. Encoding, in the Social Information Processing model, is defined as selectively attending to situational and internal cues and then encoding the relevant cues. Thus, it would be important to have the ability to rapidly select the socially salient features of an interaction, in order for these cues to be interpreted and further processed in the steps that lead to behavioral enactment. Given the purported role of the amygdala in responding to socially salient stimuli (Adolphs, 1999; Schultz, Romanski et al., 2000) it is possible that this structure and associated circuitry are essential in the encoding process. The amygdala is also reported

to be an important structure in the memory of emotional and social information and may therefore be critical in the development of the database. The superior temporal sulcus (STS) is reported (Brothers, 1996) to be particularly sensitive to socially based information, such as facial expressions and the gaze of others. This area of the brain and its connections to the amygdala may also be important in the initial encoding of salient social information.

Finally, the later stages of the model represent aspects of functioning that are broadly consistent with reported areas of impairment in patients with damage to the frontal lobes. As hypothesized by Brothers (Brothers, 1996, 1997) the orbitofrontal lobe is a critical component in social functioning, primarily serving to assist with social judgment and subsequent behavior. This region has strong connections with the amygdala and these regions are thought to interact in the process of detecting and responding to socially salient information. Studies of patients with orbitofrontal damage suggest that they are "prevented from recreating, and thus accessing, important internal signals that would have guided them in choosing appropriate actions" (Brothers, 1996, p. 4). This suggests that impairment in this region could affect Encoding (particularly of internal cues), as well as functions relevant to stages that involve selecting appropriate actions (Stage 4, 5, 6). Interestingly, patients with prefrontal damage are often noted to have difficulty demonstrating appropriate behavior, despite indicating that they are aware of what they should or should not do. That is, behavior in these patients can be in direct opposition to apparently accurate encoding and interpretation of social information. This type of deficit reflects disruption in later stages of social information processing, such as response selection and response evaluation (Stage 5). Systematic investigations of a

possible dissociation between the deficits in AsD and the problems in patients with frontal lobe impairments may be useful for further defining components of social cognition, as well as refining the Social Information Processing model.

Finally, this model may be valuable with regard to developing new approaches to treatment of AsD. Thus far, treatment research has primarily focused on later stages of social information processing, typically response decision and behavioral enactment. This type of treatment, usually referred to as Social Skills Training, has not resulted in generalized improvement in AsD or autism (Ozonoff & Miller, 1995). Shifting the focus of such treatment to an earlier stage in the processing of social information may be more effective in altering social behavior. Various intervention techniques emphasizing one or more early stages of the Social Information Processing model could be empirically tested and compared.

Conclusions

The current findings both enhance and extend recent descriptions of the abnormalities in AsD and offer further support for a Primary Social Deficit explanation of the underlying impairment in this disorder. Conceptualized within the Social Information Processing model (Crick & Dodge, 1994), results suggest that the AsD group has potential deficits in the social database, encoding of social information, and interpretation of social cues. This model may be a useful framework for future investigations of social deficits in AsD and other populations with proposed social processing deficits.

Several of the quantitative results of this study warrant further explorations of group differences. A follow-up study will involve a detailed qualitative analysis of the

transcribed verbal output of all subjects obtained during the Social Scenes task. Given the interesting observations noted by the examiners during testing, it is expected that this qualitative approach will yield important information about the AsD group's approach to processing the scenes. In addition, subsequent studies will focus on replicating the highlighted findings in another group of individuals with AsD, and then on extensions of these investigations to include other clinical populations with observed social difficulties. Overall, the current findings reveal several promising directions for future research seeking to identify and characterize the social processing deficits in Asperger's Disorder.

References

Adolphs, R. (1999). Social cognition and the human brain. *Trends in Cognitive Neuroscience, 3*(12), 469-479.

American Psychological Association. (1994). *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.). Washington, DC: Author.

Bachevalier, J. (1994). Medial temporal lobe structures and autism: A review of clinical and experimental findings. *Neuropsychologia, 32*, 627-648.

Baron-Cohen, S., & Hammer, J. (1997). Parents of children with Asperger syndrome: What is the cognitive phenotype? *Journal of Cognitive Neuroscience, 9*(4), 548-554.

Baron-Cohen, S., Jolliffe, T., Mortimore, C., & Robertson, M. (1997). Another advanced test of theory of mind: Evidence from very high functioning adults with autism or Asperger syndrome. *Journal of Child Psychology and Psychiatry, 38*, 813-822.

Baron-Cohen, S., & Ring, H. (1994). A model of the mindreading system: Neuropsychological and neurobiological perspectives. In C. L. P. Mitchell (Ed.), *Origins of an understanding of mind*. Hillsdale, NJ: Lawrence Erlbaum.

Baron-Cohen, S., Ring, H. A., Bullmore, E. T., Wheelright, S., Ashwin, C., & Williams, S. C. R. (2000). The amygdala theory of autism. *Neuroscience and Biobehavioral Reviews, 24*, 355-364.

Baron-Cohen, S., Ring, H. A., Wheelwright, S., Bullmore, E. T., Brammer, M. J., Simmons, A., & Williams, S. C. R. (1999). Social intelligence in the normal and autistic brain: An fMRI study. *European Journal of Neuroscience, 11*, 1891-1898.

Baron-Cohen, S., Wheelwright, S., Hill, J., Raste, Y., & Plumb, I. (2001). The "Reading the Mind in the Eyes" test revised version: A study with normal adults, and adults with Asperger syndrome or high-functioning autism. *Journal of Child Psychology and Psychiatry, 42*, 241-251.

Baron-Cohen, S., Wheelwright, S., & Jolliffe, T. (1997). Is there a "language of the eyes"? Evidence from normal adults, and adults with autism or Asperger syndrome. *Visual Cognition, 4*, 311-331.

Bauman, M. L., & Kemper, T. L. (1985). Neuroanatomic observations of the brain in autism. *Neurology, 35*, 866-874.

Bitti, P. E. R., & Poggi, I. (1991). Symbolic nonverbal behavior: Talking through gestures. In R. S. Feldman & B. Rime (Eds.), *Fundamentals of Nonverbal Behavior*. Cambridge: Cambridge University Press.

Bowler, D. M. (1992). "Theory of Mind" in Asperger's syndrome. *Journal of Child Psychology and Psychiatry, 33*, 877-893.

Bowler, D. M., Gardiner, J. M., & Grice, S. (2000). Episodic memory and remembering in adults with Asperger syndrome. *Journal of Autism and Developmental Disorders, 30*(4), 295-304.

Bowler, D. M., Gardiner, J. M., Grice, S., & Saavalainen, P. (2000). Memory illusions: False recall and recognition in adults with Asperger's syndrome. *Journal of Abnormal Psychology, 109*(4), 663-672.

Bowler, D. M., Matthews, N. J., & Gardiner, J. M. (1997). Asperger's syndrome and memory: Similarity to autism but not amnesia. *Neuropsychologia, 35*(1), 65-70.

Bransford, J. D., & Franks, J. J. (1971). The abstraction of linguistic ideas. *Cognitive Psychology, 2*, 331-350.

Brothers, L. (1990). The neural basis of primate social communication. *Motivation and Emotion, 14*(2), 81-91.

Brothers, L. (1996). Brain mechanisms of social cognition. *Journal of Psychopharmacology, 10*(1), 2-8.

Brothers, L. (1997). *Friday's footprints*. New York, NY: Oxford Press.

Brown, R., Hobson, R., & Lee, A. (1997). Are there 'autistic-like' features in congenitally blind children. *Journal of Child Psychology and Psychiatry, 38*(6), 693-703.

Cadesky, E. B., Mota, V. L., & Schachar, R. J. (2000). Beyond words: Do children with ADHD and/or conduct problems process nonverbal information about affect? *American Academy of Child and Adolescent Psychiatry, 39*(9), 1160-1167.

Calder, A. J., Lawrence, A. D., & Young, A. W. (2001). Neuropsychology of fear and loathing. *Neuroscience: Nature Reviews, 2*, 352-363.

Casanova, M. F., Buxhoeveden, D. P., & Switala, A. E. (2002). Asperger's syndrome and Cortical Neuropathology. *Journal of Child Neurology, 17*(2), 142-145.

Casanova, M. F., Buxhoeveden, D. P., Switala, A. E., & Roy, E. (2002). Minicolumnar pathology in autism. *Neurology, 58*, 428-432.

Channon, S., Charman, T., Heap, J., Crawford, S., & Rios, P. (2001). Real-life-type problem-solving in Asperger's syndrome. *Journal of Autism and Developmental Disorders, 31*(5), 461-469.

Clark, T., Freehan, C., Tinline, C., & Vostanis, P. (1999). Autistic symptoms in children with attention deficit-hyperactivity disorder. *European Journal of Child and Adolescent Psychiatry, 8*, 50-55.

Corporation, T. P. (1999). *Wechsler Abbreviated Scale of Intelligence*. San Antonio: Author.

Corrigan, P. W., Wallace, C. J., & Green, M. F. (1992). Deficits in social schemata in schizophrenia. *Schizophrenia Research, 8*(2), 129-135.

Crick, N. R., & Dodge, K. A. (1994). A review and reformulation of social information processing mechanisms in children's social adjustment. *Psychological Bulletin, 115*, 74-101.

Critchley, H. D., Daly, E. M., Bullmore, E. T., Williams, S. C. R., Van Amelsvoort, T., Robertson, D. M., Rowe, A., Phillips, M., McAlonan, G., Howlin, P., & Murphy, D. G. M. (2000). The functional neuroanatomy of social behaviour: Changes in

cerebral blood flow when people with autistic disorder process facial expressions. *Brain, 123*, 2203-2212.

Dahlgren, S. O., & Trillingsgaard, A. (1996). Theory of mind in nonretarded children with autism and Asperger's syndrome. A research note. *Journal of Child Psychology and Psychiatry, 37*, 759-763.

Davies, S., Bishop, D., Manstead, A. S. R., & Tantam, D. (1994). Face perception in children with autism and Asperger's syndrome. *Journal of Child Psychology and Psychiatry, 25*, 147-155.

Dawson, G., Carver, L., Meltzoff, A. N., Panagiotides, H., McPartland, J., & Webb, S. J. (2002). Neural correlates of face and object recognition in young children with autism spectrum disorder, developmental delay, and typical development. *Child Development, 73*(3), 700-717.

Dawson, G., Meltzoff, A. N., Osterling, J., Rinaldi, J., & Brown, E. (1998). Children with autism fail to orient to naturally occurring social stimuli. *Journal of Autism and Developmental Disorders, 28*(6), 479-485.

Dawson, G., Munson, J., Estes, A., Osterling, J., McPartland, J., Toth, K., Carver, L., & Abbott, R. (2002). Neurocognitive function and joint attention ability in young children with autism spectrum disorder versus developmental delay. *Child Development, 73*(2), 345-358.

Dyck, M. J., Ferguson, K., & Shochet, I. M. (2001). Do autism spectrum disorders differ from each other and from non-spectrum on emotion recognition tests? *Journal of Autism and Developmental Disorders, 31*, 37-45.

Eisenmajer, R., & Prior, M. (1991). Cognitive linguistic correlates of "theory of mind" ability in autistic children. *British Journal of Developmental Psychology, 9*, 351-364.

Ekman, P., & Friesen, W. V. (1976). Pictures of Facial Affect. Palo Alto, CA: Consulting Psychological Press.

Emery, N. (2000). The eyes have it: the neuroethology, function, and evolution of social gaze. *Neuroscience and Biobehavioral Reviews, 24*, 581-604.

Fine, J., Bartolucci, G., Ginsberg, G., & Szatmari, P. (1991). The use of intonation to communicate in pervasive developmental disorders. *Journal of Child Psychology and Psychiatry, 32*, 771-782.

Fine, J., Bartolucci, G., Szatmari, P., & Ginsberg, G. (1994). Cohesive discourse in pervasive developmental disorders. *Journal of Autism and Developmental Disorders, 24*(3), 315-329.

Folstein, S. E., & Santangelo, S. L. (2000). Does Asperger syndrome aggregate in families? In A. Klin & F. R. Volkmar & S. S. Sparrow (Eds.), *Asperger Syndrome* (pp. 159-171). New York: The Guildford Press.

Frith, U. (1989). *Autism: Explaining the enigma*: Blackwell, Oxford.

Frith, U. (1991). *Autism and Asperger syndrome*. Cambridge: Cambridge University Press.

Frith, U. (2001). Mind blindness and the brain in autism. *Neuron, 32*, 969-979.

Frith, U., & Happe, F. (1994). Autism: beyond "theory of mind". *Cognition, 50*, 115-132.

Garnett, M. S., & Attwood, T. (1998). The Australian scale for Asperger's syndrome. In T. Attwood (Ed.), *Asperger's Syndrome: A Guide for Professionals and Parents.* London: Jessica Kingsley Publishers.

Gauthier, I., Tarr, M. J., Anderson, A. W., Skudlarski, P., & Gore, J. C. (1999). Activation of the middle fusiform "face area" increases with expertise in recognizing novel objects. *Nature Neuroscience, 2*, 568-573.

Gillberg, C., Gillberg, I. C., & Ehlers, S. (1991). Asperger syndrome diagnostic interview.

Gillberg, C. L. (1992). The Emmanuel Miller Memorial Lecture 1991. Autism and autistic-like conditions: subclasses among disorders of empathy. *Journal of Child Psychology and Psychiatry, 33*, 813-842.

Gomez-Tortusa, E., MacDonald, M. E., Friend, J. C., Taylor, S. A., Weiler, L. J., Cupples, L. A., Srinidhi, J., Gusella, J. F., Bird, e. D., Vonsattel, J. P., & Myers, R. H. (2001). Quantitative neuropathological changes in presymptomatic Huntington's disease. *Annals of Neurology, 49*, 29-34.

Gray, J. M., Young, A. W., Barker, W. A., Curtis, A., & Gibson, D. (1997). Impaired recognition of disgust in Huntington's disease gene carriers. *Brain, 120*, 2029-2038.

Gresham, F. M., & Elliot, S. N. (1990). *Social Skills Rating Scale.* Circle Pines, MN: AGS Publishing.

Grossman, J. B., Klin, A., Carter, A. S., & Volkmar, F. R. (2000). Verbal bias in recognition of facial emotions in children with Asperger syndrome. *Journal of Child Psychology and Psychiatry, 41*(3), 369-379.

Halligan, P. W. (1998). Inability to recognize disgust in Huntington's disease. *Lancet, 351*, 464.

Happe, F., Ehlers, S., Fletcher, P., & Frith, U. (1996). 'Theory of mind' in the brain. Evidence from a PET scan study of Asperger syndrome. *NeuroReport, 8*, 197-201.

Happe, F. G. E. (1995). The role of age and verbal ability in the theory of mind task performance of subjects with autism. *Child Development, 66*, 843-855.

Heavey, L., Phillips, W., Baron-Cohen, S., & Rutter, M. (2000). The Awkward Moments Test: A naturalistic measure of social understanding in autism. *Journal of Autism and Developmental Disorders, 30*, 225-336.

Heberlein, A. S., Adolphs, R., Tranel, D., Kemmerer, D., Anderson, S., & Damasio, A. (1998). *Impaired attribution of social meanings to abstract dynamic geometric patterns following damage to the amygdala.* Paper presented at the Society for Neuroscience Abstract, Los Angeles, CA.

Hobson, R., Lee, A., & Brown, R. (1999). Autism and congenital blindness. *Journal of Autism and Developmental Disorders, 29*(1), 45-56.

Hobson, R. P. (1986a). The autistic child's appraisal of expressions of emotion. *Journal of Child Psychology and Psychiatry, 27*(3), 321-342.

Hobson, R. P. (1986b). The autistic child's appraisal of expressions of emotion: A further study. *Journal of Child Psychology and Psychiatry, 27*(5), 671-680.

Howard, M. A., Cowell, P. E., Boucher, J., Broks, P., Mayes, A., Farrant, A., & Roberts, N. (2000). Convergent neuroanatomical and behavioural evidence of amygdala hypothesis of autism. *Neuroreport, 11*(13), 2931-2935.

Jolliffe, T., & Baron-Cohen, S. (1997). Are people with autism and Asperger syndrome faster than normal on the embedded figures test? *Journal of Child Psychology, Psychiatry, and Allied Disciplines, 38*(5), 527-534.

Jolliffe, T., & Baron-Cohen, S. (1999a). The strange stories test: A replication with high-functioning adults with Autism or Asperger syndrome. *Journal of Autism and Developmental Disorders, 29*(5), 395-406.

Jolliffe, T., & Baron-Cohen, S. (1999b). A test of central coherence theory: linguistic processing in high-functioning adults with autism or Asperger syndrome: is local coherence impaired? *Cognition, 71*, 149-185.

Jolliffe, T., & Baron-Cohen, S. (2000). Linguistic processing in high-functioning adults with autism or Asperger's syndrome. Is global coherence impaired? *Psychological Medicine, 30*(5), 1169-1187.

Jolliffe, T., & Baron-Cohen, S. (2001a). A test of central coherence theory: Can adults with high functioning autism or Asperger syndrome integrate fragments of an object? *Cognitive Neuropsychiatry, 6*(3), 193-216.

Jolliffe, T., & Baron-Cohen, S. (2001b). A test of central coherence theory: Can adults with high-functioning autism or Asperger syndrome integrate objects in context? *Visual Cognition, 8*(1), 67-101.

Kaland, N., Moller-Nielsen, A., Callesen, K., Mortensen, E., Gottlieb, D., & Smith, L. (2002). A new 'advanced' test of theory of mind: evidence from children and adolescents with Asperger syndrome. *Journal of Child Psychology and Psychiatry, 43*(4), 517-528.

Kanwisher, N., McDermott, J., & Chun, M. M. (1997). The fusiform face area: A module in human extrastriate cortex specialized for face perception. *The Journal of Neuroscience, 17*, 4302-4311.

Klin, A. (2000). Attributing social meaning to ambiguous visual stimuli in higher-functioning autism and Asperger syndrome: The social attribution task. *Journal of Child Psychology and Psychiatry, and Allied Disciplines, 41*(7), 831-846.

Klin, A., Jones, W., Schultz, R., Volkmar, F., & Cohen, D. (2002). Visual fixation patterns during viewing of naturalistic social situations as predictors of social competence in individuals with autism. *Archives of General Psychiatry, 59*(9), 809-816.

Klin, A., & Volkmar, F. R. (1997). Asperger's syndrome. In D. J. Cohen & F. R. Volkmar (Eds.), *Handbook of autism and pervasive developmental disorders.* (Vol. 2nd Edition, pp. 94-122). New York: Wiley.

Landa, R. (2000). Social language use in Asperger syndrome and high-functioning autism. In A. Klin & F. R. Volkmar & S. S. Sparrow (Eds.), *Asperger Syndrome* (pp. 125-155). New York: Guilford Press.

LeDoux, J. E. (1994). Emotion, memory, and the brain. *Scientific American, 270*(6), 50-57.

Lincoln, A., Courchesne, E., Allen, M., Hanson, E., & Ene, M. (1998). Neurobiology of Asperger syndrome: Seven case studies and quantitative magnetic resonance imaging findings. In G. B. E. Schopler, Mesibov, & L. J. Kunce (Ed.), *Asperger syndrome or high-functioning autism.* (pp. 79-106). New York: Plenum Press.

Loveland, K., Tunali-Kotoski, B., Chen, R., Brelsford, K., Ortegon, J., & Pearson, D. (1995). Intermodal perception of affect in persons with autism or down syndrome. *Development and Psychopathology, 7*, 409-418.

Loveland, K., Tunali-Kotoski, B., Chen, Y., Ortegon, J., Pearson, D., Brelsford, K., & Gibbs, M. (1997). Emotion recognition in autism: Verbal and nonverbal information. *Development and Psychopathology, 9*, 579-593.

McAlonan, G. M., Daly, E., Kumari, V., Critchley, H. D., Van Amelsvoort, T., Suckling, J., Simmons, A., Sigmundsson, T., Greenwood, K., Russell, A., Schmitz, N., Happe, F., Howlin, P., & Murphy, D. G. M. (2002). Brain anatomy and sensorimotor gating in Asperger's syndrome. *Brain, 127*, 1594-1606.

Minter, M., Hobson, R., & Bishop, M. (1998). Congenital visual impairment and 'theory of mind'. *British Journal of Developmental Psychology, 16*, 183-196.

Mottron, L., & Belleville, S. (1993). A study of perceptual analysis in a high-level autistic subject with exceptional graphic abilities. *Brain and Cognition, 23*, 279-309.

Nadel, L., Samsonovich, A., Ryan, L., & Moscovitch, M. (2000). Multiple trace theory of human memory: Computational, neuroimaging, and neuropsychological results. *Hippocampus, 10*, 352 - 368.

Navon, D. (1977). Forest before trees: The precedence of global features in visual perception. *Cognitive Psychology, 9*, 353-383.

Organization, W. H. (1993). Chapter V. Mental and behavioral disorders (including disorders of psychological development). Diagnostic criteria for research, *International Classification of Diseases: Tenth revision*. Geneva: World Health Organization.

O'Riordan, M., & Plaisted, K. (2001a). Enhanced discrimination in autism. *The Quarterly Journal of Experimental Psychology, 54A*(4), 961-979.

O'Riordan, M., & Plaisted, K. (2001b). Superior visual search in autism. *Journal of Experimental Psychology: Human Perception and Performance, 27*(3), 719-730.

Osterling, J., & Dawson, G. (1994). Early recognition of children with autism: A study of first birthday home videotapes. *Journal of Autism and Developmental Disorders, 24*(3), 247-257.

Osterling, J., Dawson, G., & Munson, J. (2002). Early recognition of 1-year-old infants with autism spectrum disorder versus mental retardation. *Development and Psychopathology, 14*, 239-251.

Ozonoff, S., & Miller, J. N. (1995). Teaching theory of mind: A new approach to social skills training for individuals with autism. *Journal of Autism and Developmental Disorders, 25*(4), 415-433.

Pierce, K., Glad, K., & L, S. (1997). Social perception in children with autism: An attention deficit? *Journal of Autism and Developmental Disorders, 27*(3), 265-282.

Rapport, L. J., Friedman, S. L., Tzelepis, A., & Van Voorhis, A. (2002). Experienced emotion and affect recognition in adult attention-deficit hyperactivity disorder. *Neuropsychology, 16*(1), 102-110.

Rieffe, C., Meerum Terwogt, M., & Stockman, L. (2000). Understanding atypical emotions among children with autism. *Journal of Autism and Developmental Disorders, 30*(3), 195-203.

Rinehart, N. J., Bradshaw, J. L., Brereton, A. V., & Tonge, B. J. (2002). Lateralization in individuals with high-functioning austim and Asperger's disorder: A frontostriatal model. *Journal of Autism and Developmental Disorders, 32*(4), 321-331.

Rinehart, N. J., Bradshaw, J. L., Simon, A. M., Brereton, A. V., & Tonge, B. J. (2000). Atypical interference of local detail on global processing in high-functioning autism and Asperger's disorder. *Journal of Child Psychology, Psychiatry, and Allied Disciplines, 41*(6), 769-778.

Rodgers, J. (2000). Visual perception and Asperger syndrome: Central coherence deficit or hierarchization deficit? *Autism: The International Journal of Research and Practice, 4*(3), 321-329.

Roeyers, H., Buysse, A., Ponnet, K., & Pichal, B. (2001). Advancing advanced mind-reading tests: empathic accuracy in adults with a pervasive development disorder. *Journal of Child Psychology & Psychiatry & Allied Disciplines, 42*(2), 271-278.

Rutherford, M. D., Baron-Cohen, S., & Wheelwright, S. (2002). Reading the mind in the voice: A study with normal adults and adults with Asperger syndrome and high functioning autism. *Journal of Autism and Developmental Disorders, 32*(3), 189-194.

Sacks, O. (1995). *An Anthropologist on Mars*. Toronto: Random House of Canada.

Scheuffgen, K., Happe, F., Anderson, M., & Frith, U. (2000). High "intelligence," low "IQ"? Speed of processing and measured IQ in children with autism. *Development and Psychopathology, 12*, 83-90.

Schultz, R. T., Gauthier, I., Klin, A., Fulbright, R. K., Anderson, A. W., Volkmar, F., Skudlarski, P., Lacadie, C., Cohen, D. J., & Gore, J. C. (2000). Abnormal ventral temporal cortical activity during face discrimination among individuals with autism and Asperger syndrome. *Archives of General Psychiatry, 57*, 331-340.

Schultz, R. T., Romanski, L. M., & Tsatsanis, K. D. (2000). Neurofunctional models of autistic disorder and Asperger syndrome: Clues from neuroimaging. In A. Klin & V. F. R. & S. S. Sparrow (Eds.), *Asperger Syndrome*. New York: Guilford Press.

Singh, S. D., Ellis, C. R., Winton, A. S., Singh, N. N., Leung, J. P., & Oswald, D. P. (1998). Recognition of facial expressions of emotion by children with attention-deficit hyperactivity disorder. *Behavior Modification, 22*, 128-142.

Sprengelmeyer, R., Young, A. W., Calder, A. J., Karnat, A., Lange, H., Homberg, V., Perrett, D. I., & Rowland, D. (1996). Loss of disgust: perception of faces and emotions in Huntington's disease. *Brain, 119*, 1647-1665.

Szatmari, P. (2000a). The classification of autism, Asperger's syndrome, and pervasive developmental disorder. *Canadian Journal of Psychiatry, 45*, 731-738.

Szatmari, P. (2000b). Perspectives on the classification of Asperger syndrome. In A. Klin & F. R. Volkmar & S. S. Sparrow (Eds.), *Asperger Syndrome* (pp. 403-417). New York: Guilford Press.

Tantam, D. (1992). Characterizing the fundamental social handicap in autism. *Acta Paedopsychiatrica, 55*, 83-91.

Tantam, D., Holmes, D., & Cordess, C. (1993). Nonverbal expression in autism of the Asperger type. *Journal of Autism and Developmental Disorders, 23*, 111-133.

Volkmar, F. R., & Klin, A. (2000). Diagnostic issues in Asperger syndrome. In A. Klin & F. R. Volkmar & S. S. Sparrow (Eds.), *Asperger Syndrome* (pp. 25-71). New York: Guilford Press.

Whalen, P. J., Shin, L. M., McInerney, S. C., Fischer, H., Wright, C. I., & Rauch, S. L. (2001). A functional MRI study of human amygdala responses to facial expressions of fear vs. anger. *Emotion, 1*, 70-83.

Willemsen-Swinkels, S., Buitelaar, J., Weijnen, F., & van Engeland, H. (1998). Timing of social gaze behavior in children with a pervasive development disorder. *Journal of Autism and Developmental Disorders, 28*(3), 199-210.

Wing, L. (1981). Asperger's syndrome: A clinical account. *Psychological Medicine, 11*, 115-129.

World Health Organization. (1993). Chapter V. Mental and behavioral disorders (including disorders of psychological development). Diagnostic criteria for research, *International Classification of Diseases: Tenth revision*. Geneva: World Health Organization.

Appendix A

DEVELOPMENTAL HISTORY QUESTIONNAIRE

This student is presently living with ☑ __ Biological Mother __ Biological Father __Stepfather __Stepmother __Adoptive Mother __Adoptive Father __Foster Mother __Foster Father __Siblings: How many brothers: _____ (ages:) sisters: _____ (ages:) __Other people in home (please specify):

Pregnancy – please ☑ if these complications apply, and provide details (e.g., hospitalizations, diagnoses) for those complications that do apply.
__Excessive vomiting
__Excessive staining/blood loss
__Infection(s)
__Toxemia
__Other illnesses
__Smoking during pregnancy – if so, how many cigarettes per day: _____
__Alcoholic consumption during pregnancy - if so, how much per day or per week: _____
__Medications taken during pregnancy
__X-ray studies during pregnancy
Duration of pregnancy (months or weeks):

Delivery Type of labour: __Spontaneous __Induced Type of delivery: __Normal __Breech __Cesarean	
Duration of labour:	Birth weight:
Duration of Pregnancy (i.e., labour was early, late, or on time):	

Complications: __Cord around neck __Hemorrhage __Infant injured during delivery __Other (please specify): If any of these were a problem, please explain:
Post Delivery __Jaundice __Cyanosis (turned blue) __Incubator Care __Infection (specify): __Number of days infant was in hospital after delivery:

Infancy Period – Were any of the following present to a significant degree during the first few years of life? If so, please ☑ and describe.	
__Did not enjoy cuddling	
__Was not calmed by being held or stroked	
__Difficult to comfort	
__Colic	__Excessive restlessness
__Excessive irritability	
__Diminished sleep	
__Frequent head banging	
__Difficulty nursing/feeding	
__Constantly into everything	

Temperament – Please rate the following behaviors as he/she appeared during infancy and toddlerhood
Activity Level – How active has he/she been from an early age?
Distractibility – How easily was his/her attention diverted?
Adaptability – How well did he/she deal with transition and change?
Approach/Withdrawal – How well did he/she respond to new things (i.e., places, people, food, routines, etc.)?
Intensity – Whether happy or unhappy, how aware are others of his/her feelings?

Mood – What was his/her basic mood?
Regularity – How predictable was he/she in patterns of sleep, appetite, etc.?
Persistence & Attention – How well was he/she able to persist in attaining a goal and to attend to one activity for a long time?
Sensory Threshold – Was he/she over or under sensitive to light, sound, and textures?

Medical History – If his/her medical history includes any of the following, please ☑, and then note the **age** when the incident or illness occurred, and **any other pertinent information.**
__Childhood diseases (describe ages and any complications)
__Operations
__Hospitalizations for illness
__Investigations of Brain function (i.e., EEG, CT scan, MRI): If yes, when and what were the results:
__Head injuries (please state if there was a Loss of consciousness)
__Convulsions: __with fever __without fever
__Persistent high fevers
__Eye problems
__Tics (i.e., eye blinking, sniffing; any repetitive, non-purposeful movements)
__Ear problems
__Allergies or Asthma
__Poisoning

Sleep (at the present time)	yes	no	Comments
Does he/she settle down to sleep?	__	__	
Sleep through the night without disruption?	__	__	
Experience nightmares, sleep walking/talking?	__	__	
Is a very restless sleeper?	__	__	
Any changes in sleep patterns in the past 6 months?	__	__	

How is his/her appetite?

Any changes in appetite in the past 6 months? __No __Yes

Present Medical Status

Any illnesses for which he/she is currently being treated?

Medications he/she is taking on an ongoing basis?

Psychiatric History

Has he/she ever been diagnosed with a psychiatric disorder or psychological problem (i.e., Depression, Conduct Disorder, Attention Deficit/Hyperactivity Disorder)? __No __Yes – if so, when? Please describe:

Has he/she ever received psychological treatment or counseling? __No __Yes – if so, when and for what reason?

Has he/she been exposed to physical/emotional abuse? __No __Yes – if so, please explain:

To the best of your knowledge, has he/she:

__consumed alcohol
__taken illegal drugs
__violated the law
__destroyed property

Is there an ongoing problem in any of these areas? ?No ?Yes - if so, please explain.

Past or Current Medications for Psychological/Behavioural Problems:

Date	Prescription	Dose	Response	Physician

Developmental Milestones – If you can recall, record the age at which he/she reached the following milestones. If you cannot recall exactly, ☑ early, normal, or late.

	Age	Early	Normal	Late
Smiled	_____	__	__	__
Sat without support	_____	__	__	__
Crawled	_____	__	__	__
Stood without support	_____	__	__	__
Walked without assistance	_____	__	__	__
Spoke first words	_____	__	__	__
Said phrases	_____	__	__	__
Said sentences	_____	__	__	__
Bladder trained, day	_____	__	__	__
Bladder trained, night	_____	__	__	__
Bowel trained, day	_____	__	__	__
Bowel trained, night	_____	__	__	__
Rode tricycle	_____	__	__	__
Rode bicycle (without training wheels)	_____	__	__	__
Buttoned clothing	_____	__	__	__
Tied shoelaces	_____	__	__	__
Named colours	_____	__	__	__
Named coins	_____	__	__	__
Said alphabet in order	_____	__	__	__
Began to read		__	__	__

Coordination – Please rate the following skills (at the present time)

	Good	Average	Poor
Walking	__	__	__
Running	__	__	__
Throwing	__	__	__
Catching	__	__	__
Writing	__	__	__
Athletic abilities	__	__	__
Number of accidents (compared to his/her peers)	__ (more)	__	__ (fewer)

Comprehension & Understanding

Do you consider him/her to understand instructions and situations as well as other his/her peers? If not, why not?

How would you rate his/her overall level of intelligence compared to peers? Below Average __ Average __ Above Average __

School History

Has he/she experienced any difficulty in school related to *academics*? __No __Yes - If yes, please explain.

Has he/she ever had to repeat a grade? __No __Yes, if yes, when?

Describe any special counseling or remedial work he/she has received. When did this occur? Please describe the type of services he/she had (i.e., speech -language therapy, IEP).

Has he/she experienced any difficulty in school related to *behaviour?* __No __Yes - If yes, please explain.

Please any of the following behaviors that teachers have reported as significant classroom problems? Please indicate when and if this problem still occurs.

__Doesn't sit still in his or her seat
__Frequently gets up and walks around
__Shouts out, doesn't wait to be called on
__Won't wait his or her turn
__Doesn't cooperate well in group activities
__Does better in one-to-one activities
__Doesn't respect the rights of others
__Doesn't pay attention

Peer Relationships

Does he/she seek friendship with peers?

Do peers seek him/her for friendship?

Are his/her friends mainly __older, __younger, or __the same age? (☑ one)

Has behaviour caused him/her to be neglected by peers? If yes, please explain.

Describe briefly any problems with peers and social relationships.

Home Behaviour – All young people exhibit, to some degree, the behaviours listed below. ☑ those that you believe he/she exhibits to an excessive or exaggerated degree when compared to other individuals of his or her age.
__Fidgets with hands, feet, or squirms in seat.
__Has difficulty remaining seated when required to do so.
__Easily distracted by extraneous stimuli.
__Has difficulty awaiting turn in games or group situations.
__Blurts out answers to questions before they have been completed.
__Has problems following through with instructions (not due to opposition or comprehension).
__Has difficulty paying attention during tasks or play activities.
__Shifts from one uncompleted activity to another.
__Has difficulty playing quietly.
__Often talks excessively.
__Interrupts or intrudes on others (often not purposeful or planned, but impulsive).
__Does not appear to listen to what is being said.
__Loses things necessary for tasks or activities at home.
__Boundless energy and poor judgment.
__Impulsivity (poor self-control)
__History of temper tantrums.
__Temper outbursts.
__Frustrates easily.
__Sloppy table manners.
__Sudden outbursts of physical abuse of other children.
__Overly anxious/worried.
__Low mood/withdrawn
__Severe sibling rivalry
__Acts like he or she is driven by a motor.
__Wears out shoes more frequently than siblings.
__Excessive number of accidents.
__Doesn't seem to learn from experience.
__Poor memory
__A "different child"

Family History
Following is a list of psychiatric disorders, medical problems, and learning related problems. Please ☑ any of these that has affected (either in the past or at the present time) any ***biological*** family member of the student for which you are completing this form. If any of these disorders are present in the family, please indicate which family member is affected (i.e., paternal aunt, maternal cousin, etc.).
__Depression
__Manic-Depressive Disorder (i.e. Bipolar)
__Anxiety (including Panic Attacks)
__Obsessive-Compulsive Disorder
__Schizophrenia
__Attention Deficit/Hyperactivity Disorder
__Learning Disability - If yes, please describe type of problem(s).
__Autism
__Asperger's Disorder
__Epilepsy
__Any other notable medical, psychiatric, or learning problem that has not been discussed elsewhere in this form?

Appendix B

Family History Form

This part of the questionnaire is meant to gather information about your son/daughter's genetic history. Please complete the sections for both biological parents. In addition, please complete one section for each biologically related family member that has (or has had in the past) any of the difficulties listed below. Please consider biological siblings, aunts, uncles, cousins, and grandparents. If there are any more distant relatives who share similar personality features with your son/daughter, please include them also. When describing how family members are related to your son/daughter, please be specific, including such information as whether they are related on the mother's side or father's side, whether siblings and aunts or uncles are full or half siblings of the child or the child's parents, etc.

Biological Mother	
Age (current):	Age at time of pregnancy with this child:
Highest grade completed:	Occupation:
History of: (please describe each in as much detail as possible)	
Learning problems:	
Attention problems:	
Behaviour problems:	
Emotional/psychiatric problems:	
Social difficulties:	
Medical problems:	
Prescriptions used for past/present psychiatric problems:	
Please describe, to the best of your ability, any notable personality features about this individual, particularly those that are similar to your son/daughter:	

Biological Father	
Age (current):	Age at the time of this child's conception:
Highest grade completed:	Occupation:
History of: (please describe each in as much detail as possible)	
Learning problems:	
Attention problems:	
Behaviour problems:	
Emotional/psychiatric problems:	
Social difficulties:	
Medical problems:	
Prescriptions used for past/present psychiatric problems:	
Please describe, to the best of your ability, any notable personality features about this individual, particularly those that are similar to your son/daughter:	

ADDITIONAL FAMILY MEMBERS

#1

Relationship to child (please be specific):	
Current Age:	
Highest grade completed:	Occupation:
History of: (please describe each in as much detail as possible)	
Learning problems:	
Attention problems:	

Behaviour problems:
Emotional/psychiatric problems:
Social difficulties:
Medical problems:
Prescriptions used for past/present psychiatric problems:
Please describe, to the best of your ability, any notable personality features about this individual, particularly those that are similar to your son/daughter:

NOTE: #2 – 10 not shown here. Format was the same as indicated by Additional Family Member #1.

Asperger's Disorder - Please answer the following questions with regard to your son/daughter's diagnosis of Asperger's Disorder.

When was your son/daughter first diagnosed with Aspergers?
Who made this diagnosis? (i.e., name and profession)
Were there other diagnoses prior to Asperger's? If yes, what and when?
When did you first notice your son/daughter's social difficulties? Please describe.
When did you first notice your son/daughter's narrow interests and/or repetitive behaviours? Please describe.

What is his/her current interest(s)?
What professionals have been involved with your son/daughter? Please specify the occupation of each.
What treatments or interventions has your son/daughter received for this disorder?

Appendix C

Behavioural Questionnaire

For each question, please rate how frequently your son/daughter displays the behaviour, which is described. Think about his/her behaviour as compared to his/her peers. A rating of 0 = Rarely and a rating of 6 = Frequently. Feel free to explain your responses.

1. Does your son/daughter lack an understanding of how to interact with peers? For example, unaware of the unwritten rules of social play?

   0 1 2 3 4 5 6

2. When free to interact with other children, such as school lunchtime, does your son/daughter avoid contact with them? For example, finds a secluded place or goes to the library.

   0 1 2 3 4 5 6

3. Does your son/daughter appear unaware of social conventions or codes of conduct and make inappropriate actions and comments? For example, making a personal comment to someone, but seeming unaware of how the comment might offend.

   0 1 2 3 4 5 6

4. Does the child lack empathy (i.e., the intuitive understanding of another person's feelings)? For example, not realizing an apology would help the other person feel better.

   0 1 2 3 4 5 6

5. Does your son/daughter seem to expect other people to know his/her thoughts, experiences, or opinions? For example, not realizing you could not know about something because you were not with him/her at the time.

   0 1 2 3 4 5 6

6. Does your son/daughter need an excessive amount of reassurance, especially if things are changed or go wrong?

   0 1 2 3 4 5 6

7. Does your son/daughter lack subtlety in their expression of emotion? For example, he/she shows distress or affection out of proportion to the situation.

0 1 2 3 4 5 6

8. Does your son/daughter lack precision in their expression of emotion? For example, not understanding the levels of emotional expression appropriate for different people.

0 1 2 3 4 5 6

9. Is your son/daughter not interested in participating in competitive sports, games, and activities? 0 means the child enjoys competitive sports.

0 1 2 3 4 5 6

10. Is your son/daughter indifferent to peer pressure? For example, does not follow the latest trends or crazes in toys or clothes. 0 means he/she follows crazes.

0 1 2 3 4 5 6

11. Does your son/daughter take a literal interpretation of comments? For example, is confused by phrases such as "hop up on the scales" or "looks can kill".

0 1 2 3 4 5 6

12. Does your son/daughter have an unusual tone of voice? For example, he/she seems to have a "foreign" accent or monotone that lacks emphasis on key words.

0 1 2 3 4 5 6

13. When in a conversation, does you son/daughter tend to use less eye contact than you would expect?

0 1 2 3 4 5 6

14. Is his/her speech over-precise or pedantic? For example, talks in a formal way or like a "walking dictionary".

0 1 2 3 4 5 6

15. Does your son/daughter have problems repairing a conversation? For example, when he/she is confused, he/she does not ask for clarification, but instead switches to a familiar topic or takes a long time to reply.

0 1 2 3 4 5 6

16. Does you son/daughter read books primarily for information, not seeming to be interested in fictional works? For example, being an avid reader of encyclopedias and science books, but not interested in adventure stories.

0 1 2 3 4 5 6

17. Does your son/daughter have an exceptional long-term memory for events and facts? For example, remembering the neighbor's license plate number from several years ago, or clearly recalling scenes that happened many years ago.

0 1 2 3 4 5 6

18. Does your son/daughter lack social imaginative play? For example, his/her peers are not included in imaginary games or he/she is confused by the pretend games that others play.

0 1 2 3 4 5 6

19. Is your son/daughter fascinated by a particular topic and avidly collects information or statistics on that interest? For example, he/she becomes a walking encyclopedia of knowledge on vehicles, maps, or train schedules.

0 1 2 3 4 5 6

20. Does your son/daughter become very upset by changes in routine or expectations? For example, is distressed by going to school a different route.

0 1 2 3 4 5 6

21. Does your son/daughter develop elaborate routines or rituals that must be completed? For example, lining up particular objects in his/her room before going to bed.

0 1 2 3 4 5 6

22. Does your son/daughter have poor motor coordination? For example, is not skilled at catching a ball.

0 1 2 3 4 5 6

23. Does your son/daughter have an odd gait when running?

0 1 2 3 4 5 6

24. Was your son/daughter's language development delayed?

0 1 2 3 4 5 6

25. Does your son/daughter make limited use of gestures?

0 1 2 3 4 5 6

26. Is your son/daughter's body language awkward/gauche/clumsy/strange/unusual?

0 1 2 3 4 5 6

Appendix D

Summary of Social Scenes

1. **Summary: Asking a stranger for directions**
   Type of Scene: Abnormal Nonverbal
   Problem: Stranger disregards the personal space of the person asking for directions, inappropriate physical contact

2. **Summary: One friend assumes the other is pregnant**
   Type of Scene: Verbal Faux Pas
   Problem: The assumption implies that the friend is overweight

3. **Summary: Three people in living room, discussing birth of nephew**
   Type of Scene: Abnormal Nonverbal
   Problem: Two people engaged in conversation, the third person is ignored despite his efforts to participate.

4. **Summary: Asking a friend to borrow 5 dollars**
   Type of Scene: Action slip
   Problem: The friend agrees and takes out his wallet; she walks away with his wallet.

5. **Summary: Two friends engaged in conversation**
   Type of Scene: Abnormal Nonverbal
   Problem: No eye contact is made throughout the conversation

6. **Summary: Job Interview**
   Type of Scene: Abnormal Nonverbal
   Problem: The interviewee demonstrates inappropriate body posture; he is slouched in his chair and too relaxed for the situation.

7. **Summary: Waitress takes the order of two customers at a restaurant**
   Type of Scene: Abnormal Nonverbal
   Problem: Waitress speaks in a monotone voice and displays an absence of facial expression

8. **Summary: Group of five friends gathered, one leaves the room**
   Type of Scene: Action Slip
   Problem: When she leaves the room, she turns off the light, leaving the rest of the group in the dark

9. **Summary: Two friends meet on the street, discuss recent events**
   Type of Scene: Verbal Faux Pas
   Problem: Younger friend makes an inappropriate comment about the older friend's age

10. **Summary: Two friends in a discussion about recent events**
    Type of Scene: Normal

11. **Summary: Asking a stranger for directions**
    Type of Scene: Normal

12. **Summary: Two friends put on coats as they prepare to go out**
    Type of Scene: Action Slip
    Problem: They both zip up coats before putting them on over their heads

13. **Summary: A friend apologizes**
    Type of Scene: Normal

14. **Summary: Two friends conversing about a recent event**
    Type of Scene: Abnormal Nonverbal
    Problem: One woman is not engaging in the conversation, minimal responses

15. **Summary: Two acquaintances meet after not seeing each other for a long time**
    Type of Scene: Normal

16. **Summary: A friend asks the other for a set of car keys**
    Type of Scene: Action Slip
    Problem: The friend agrees, but hands her a bottle instead of keys

17. **Summary: Woman shops at an art store and is assisted by salesperson**
    Type of Scene: Abnormal Nonverbal
    Problem: Salesperson interrupts the customer repeatedly

18. **Summary: Two acquaintances meet after not seeing each other for a long time**
    Type of Scene: Verbal Faux Pas
    Problem: One of the men states "you used to be so handsome" without realizing the insult of the statement

19. **Summary: Woman tells friend about recent events**
    Type of Scene: Normal

20. **Summary: Two friends apologize after a recent argument**
    Type of Scene: Abnormal Nonverbal
    Problem: Tone of voice is inconsistent with the content of the conversation

21. **Summary: Two friends meet on the street and decide to go for dinner**
    Type of Scene: Normal

22. **Summary: Woman searches the room for her glasses**
    Type of Scene: Action Slip
    Problem: The glasses are on the top of her head

23. **Summary: A waitress takes the order of two customers**
    Type of Scene: Normal

24. **Summary: Man finishes hanging his new curtains as his friend arrives**
    Type of Scene: Verbal Faux Pas
    Problem: Friend indicates that he dislikes the curtains without realizing they were hand picked by the owner

25. **Summary: A new student is shown around the student lounge**
    Type of Scene: Abnormal Nonverbal
    Problem: Student does not make eye contact with the person showing her around

26. **Summary: Two friends watching television, the phone rings**
    Type of Scene: Action Slip
    Problem: One man asks the other to let him speak with the caller when he is finished; instead he hangs up without passing the phone

27. **Summary: A man thanks his friend for recent assistance with assignment**
    Type of Scene: Abnormal Nonverbal
    Problem: He touches her and tries to hug her even though her body language is closed and she appears uncomfortable

28. **Summary: Friend speaks to another about the importance of exercise**
    Type of Scene: Verbal Faux Pas
    Problem: He unintentionally criticizes the other friend's interests and way of life

29. **Summary: One friend asks another if he's attending the upcoming party**
    Type of Scene: Verbal Faux Pas
    Problem: She doesn't realize that he has not been invited to the party and was previously unaware of it

30. **Summary: Two strangers at a bus stop; one asks the other for the time**
    Type of Scene: Normal

31. **Summary: An employee and employer in meeting to discuss upcoming work**
    Type of Scene: Normal

32. **Summary: Two friends preparing to go out, putting on shoes and jackets**
    Type of Scene: Action Slip
    Problem: The man ties his shoes before putting them on

33. **Summary: Woman comments to her friend about the friend's recent date**
    Type of Scene: Verbal Faux Pas
    Problem: The woman points out the faults of her friend's date without realizing he's become a boyfriend

34. **Summary: A woman is shopping for a lamp and is helped by a salesperson**
    Type of Scene: Normal

35. **Summary: Two strangers waiting at the bus stop**
    Type of Scene: Abnormal Nonverbal
    Problem: One man stands too close to the other and continues to speak to him despite a lack of responsiveness from him

36. **Summary: Daughter gives her father a birthday gift**
    Type of Scene: Normal

37. **Summary: Father and daughter engaged in a serious discussion**
    Type of Scene: Action Slip
    Problem: He puts many spoonfuls of sugar in his coffee during the discussion

38. **Summary: Job interview**
    Type of Scene: Normal

39. **Summary: Waitress takes the order of two customers**
    Type of Scene: Abnormal Nonverbal
    Problem: The waitress looks only at the woman, although she verbally responds to both customers

40. **Summary: Friend stops by for a visit**
    Type of Scene: Action Slip
    Problem: He asks for a glass of water, she returns from the kitchen with an orange

41. **Summary: Student asks professor for lecture notes**
    Type of Scene: Normal

42. **Summary: Two friends meet for breakfast**
    Type of Scene: Verbal Faux Pas
    Problem: She asks him if he got up late, implying that he looks unkempt

43. **Summary: Friend brings a birthday gift**
    Type of Scene: Abnormal Nonverbal
    Problem: Person receiving the gift states that she is pleased with the gift, but expresses no emotion via voice or face

44. **Summary: Two acquaintances meet in their mutual dormitory**
    Type of Scene: Normal

45. **Summary: Two friends talk about the events of the weekend**
    Type of Scene: Abnormal Nonverbal
    Problem: The woman dominates the conversation, interrupting the man several times; exhibiting a lack of turn taking

46. **Summary: Man stops by his friend's house to borrow a book**
    Type of Scene: Action Slip
    Problem: Woman hands him the book, they briefly sit down to chat, and then he leaves without the book

47. **Summary: Two acquaintance discuss recent events**
    Type of Scene: Verbal Faux Pas
    Problem: She asks about his recent illness, assuming that his baldness indicates that he has been ill

48. **Summary: Student meets with professor regarding a recent exam**
    Type of Scene: Abnormal Nonverbal
    Problem: The student interrupts the professor several times as he attempts to answer her questions

49. **Summary: Two friends admiring the view**
    Type of Scene: Normal

50. **Summary: Man tells his family member about winning the basketball game**
    Type of Scene: Abnormal Nonverbal
    Problem: His voice and speech content indicate excitement, but his body posture is restrained and inconsistent with the rest of his presentation

Appendix E

Summary of Nonverbal Signals

1. Action: Shoulder shrug, accompanied by open eyes and raised eyebrows
   Target Response: "I don't know"
   Subtype: Emotional Complex

2. Action: Eye rolling and moving head from side to side
   Target Response: Annoyance, frustration
   Subtype: Emotional Simple

3. Action: Index finger to mouth
   Target Response: "Be quiet"
   Subtype: Non-Emotional

4. Action: Placing open palm on forehead
   Target Response: "Of course.." or "I get it now"
   Subtype: Emotional Complex

5. Action: Fake Yawn with open hand patting mouth
   Target Response: Boredom
   Subtype: Emotional Simple

6. Action: Hand motion, back of hand outward
   Target Response: "Go away"
   Subtype: Non-Emotional

7. Action: Tapping hand on desk, accompanied by impatient facial expression
   Target Response: annoyance, impatience
   Subtype: Emotional Complex

8. Action: Hanging head, shoulders raised, accompanied by shy look
   Target Response: Shyness
   Subtype: Emotional Complex

9. Action: Moving head from side-to-side
   Target Response: No
   Subtype: Non-Emotional

10. Action: Fingers of one hand gently scratch the top/back of head
    Target Response: Confusion
    Subtype: Emotional Simple

11. Action: Pacing, accompanied by worried facial expression
    Target Response: anxious, worried
    Subtype: Emotional Complex

12. Action: Stomping foot
    Target Response: Angry, upset
    Subtype: Emotional Simple

13. Action: Open hand out in front, palm up
    Target Response: "Can I have some?"
    Subtype: Non-Emotional

14. Action: Fingers closed in fist and thumb facing up on one hand
    Target Response: good, OK, positive response
    Subtype: Non-Emotional

15. Action: Arm raised, hand closed in fist, except for index finger points upward
    Target Response: wait, hold on
    Subtype: Non-Emotional

16. Action: Arm raised, hand opened, index finger and thumb form a circle
    Target Response: "OK" sign, good, fine
    Subtype: Non-Emotional

17. Action: Hand opened, arm raised and palm side of hand faces outward
    Target Response: Stop
    Subtype: Non-Emotional

18. Action: Index finger and thumb of one hand slowly rub the chin
    Target Response: Thinking, wondering
    Subtype: Emotional Simple

19. Action: Hands on hips, accompanied by stern facial expression??
    Target Response: Angry, upset
    Subtype: Emotional Complex

20. Action: Makes a fist with one hand and drives it into the open palm of the other
    Target Response: Angry, aggressive
    Subtype: Emotional Complex

21. Action: Crossing arms tightly across torso, lifting shoulders up towards ears, accompanied by pained look and tight mouth
    Target Response: Cold
    Subtype: Emotional Complex

22. Action: Hanging head, cupping it in both hands
    Target Response: Embarrassed, made a mistake
    Subtype: Emotional Simple

23. Action: Placing both arms in the air in the shape of a V
    Target Response: excitement, indication of victory
    Subtype: Emotional Simple

24. Action: Moving head up and down
    Target Response: Yes
    Subtype: Non-Emotional

25. Action: Raising one arm to close off nose with finger and thumb
    Target Response: something smells foul
    Subtype: Non-Emotional

26. Action: Hands at chest height, wringing them rapidly, eyes wide
    Target Response: Nervousness, anxious
    Subtype: Emotional Simple

27. Action: Raises hand to ear, turns head slightly, cups ear with open hand with palm facing forward
    Target Response: I can't hear you, speak louder please
    Subtype: Non-Emotional

28. Action: Hand in shape of fist facing upward, except index finger which repeatedly extends and bends
    Target Response: Come here
    Subtype: Non-Emotional

29. Action: Arms crossed over chest and one foot is tapping rapidly, accompanied by negative facial expression, tight mouth
    Target Response: annoyance, waiting anxiously, frustrated
    Subtype: Emotional Complex

30. Action: Raises hand to head height and moves hand from side to side in a waving motion
    Target Response: Goodbye
    Subtype: Non-Emotional

Appendix F

Emotion Definitions

Spontaneous Version

Please read each item and write down the emotion that is best defined by the statement or statements.

1. You saw something bad and it made you feel sick to your stomach.

2. You feel bad because something bad has happened to someone else.

3. You have very strong negative feelings about another person.

4. You feel good about many things in your life.

5. You feel bad because you made a mistake in front of many people.

6. You know that something very good is going to happen. You are waiting for it to occur.

7. You have been trying over and over again to do something, but you have made no progress.

8. You think that something bad might happen. You are waiting for it to occur.

9. You expected that something good would happen and you really wanted it to. In the end it did not happen.

10. You feel bad about many things in your life.

11. Someone has intentionally done something mean to you.

12. Something good happened to you, but it was very unexpected.

13. Somebody has something that you really want. You are unable to have it.

14. You have very strong positive feelings about another person.

15. There are no other people around and you miss being around people.

16. You expected that something bad would happen, but it did not.

17. Something very bad is about to happen and there is nothing you can do to stop it.

18. You worked hard to complete a task and you feel good about what you have done.

19. You feel good about something that someone else is doing. You want to find out more about it.

20. You feel bad because you have nothing to do at the moment.

Multiple Choice Version

Please read each item and circle the one emotion that is best defined by the statement or statements.

1. You saw something bad and it made you feel sick to your stomach.

Boredom Disappointment Disgust Anxiety

2. You feel bad because something bad has happened to someone else.

Sympathy Sadness Jealousy Relief

3. You have very strong negative feelings about another person.

Sadness Fear Anxiety Hate

4. You feel good about many things in your life.

Relief Happiness Interest Excitement

5. You feel bad because you mad a mistake in front of many people.

Fear Disappointment Embarrassment Disgust

6. You know that something very good is going to happen. You are waiting for it to occur.

Excitement Pride Happiness Surprise

7. You have been trying over and over again to do something, but you have made no progress.

Embarrassment Fear Hate Frustration

8. You think that something bad might happen. You are waiting for it to occur.

Fear Anxiety Disappointment Boredom

9. You expected that something good would happen and you really wanted it to. In the end, it did not happen.

Disappointment Jealousy Relief Anger

10. You feel bad about many things in your life.

Hate Fear Boredom Sadness

11. Someone has intentionally done something mean to you.

Disgust Loneliness Anger Fear

12. Something good happened to you, but it was very unexpected.

Relief Surprise Love Happiness

13. Somebody has something that you really want. You are unable to have it.

Anger Sadness Disappointment Jealousy

14. You have very strong positive feelings about another person.

Happiness Pride Love Sympathy

15. There are no other people around and you miss being around people.

Anger Loneliness Embarrassment Sadness

16. You expected that something bad would happen, but it did not.

Excitement Surprise Relief Happiness

17. Something very bad is about to happen and there is nothing you can do to stop it.

Disappointment Sadness Anger Fear

18. You worked hard to complete a task and you feel good about what you have done.

Pride Excitement Love Interest

19. You feel good about something that someone else is doing. You want to find out more about it.

Pride Interest Happiness Love

20. You feel bad because you have nothing to do at the moment.

Anger Sadness Disappointment Boredom