FACE PROCESSING ABILITIES IN CHILDREN WITH AUTISM

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The current study was comprised of three experiments that examined face processing abilities in children (aged five to seven) diagnosed with high functioning autism as compared to control participants matched on verbal mental age and chronological age. Experiment one examined recognition memory for faces using an implicit memory task in which peripheral cues for identity were removed and distinctiveness of facial stimuli was varied. Experiment two was designed to assess gender identification skills with gender stimuli that varied in the degree of typicality of gender. Experiment three examined the recognition of facial expression of emotion using dynamic stimuli that varied in the degree of expression exhibited, from subtle to exaggerated, as evidenced by increased facial muscle movement. Results indicated children with autism exhibited significantly poorer performance on all three face processing tasks, as compared to controls. Among children with high functioning autism, results of experiment one indicated that they do not capitalize on distinctive features as a way of improving memory for faces. Results of experiment two indicated that, as compared to controls, children with autism exhibited more difficulty discriminating gender, even with typical exemplars of gender. Results of experiment three suggest that children with autism found it more difficult to identify dynamic representations of facial expressions of emotion when the expressions were more subtle in presentation. Although children with autism exhibited significantly poorer performance on all three tasks, they were still able to perform at a level above chance, indicating that by the ages of five to seven, children with autism were able to process facial information, although they were developmentally delayed when compared with controls. These results are discussed in the context of several current theories of autism and the literature of both autism and typically-developing face processing abilities.

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Dedication

This document is lovingly dedicated to my daughter, Nina Giovannelli.

"The future belongs to those who believe in the beauty of their dreams."
Eleanor Roosevelt

1.0 INTRODUCTION

Autism is a developmental disorder with onset prior to age three and is characterized by qualitative impairments in social interaction and communication, as well as the presence of restricted, repetitive, and stereotyped patterns of behavior, interests and activities. Autism is part of a range of disorders that includes Asperger's Syndrome and Pervasive Developmental Disorder Not Otherwise Specified (PDD-NOS). These syndromes are jointly referred to as Autism Spectrum Disorders (ASDs). It has been proposed that the underlying neurobiological bases are shared and each individual case can be conceptualized along one or more dimensions of severity (Schultz, 2005). According to the DSM-IV, Asperger's Sydrome differs from autism in that no language delays are present early in development (American Psychiatric Association, 2000), although pragmatic language deficits are typically found by school-age. PDD-NOS is diagnosed when clinically significant social impairments are found, along with either communication or behavioral deficits, but not both. Recent epidemiological evidence suggests that the incidence of ASDs in the general population is on the rise and may now range from 1 in 300 to as high as 1 in 200 (Fombonne, 2003).

Higher prevalence rates have contributed to increased interest in attempting to understand the underlying mechanisms that may account for the specific pattern of deficits observed in those with autism. Currently, two conceptualizations of these underlying mechanisms have been the topic of debate. One conceptualization is that the deficits seen in autism are primarily domain specific social motivational/ affective in nature, rather than due to a more general cognitive deficit (Dawson, Webb & McPartland, 2005; Schultz, 2005). While social motivational/affective accounts for the deficits seen in autism are able to explain the classic diagnostic triad, as defined in the DSM-IV (American Psychiatric Association, 2000), they fail to account for documented cognitive deficits that are not related to overall intellectual functioning (e.g., Frith & Happe 1994), but are nevertheless seen in autism. An alternative conceptualization of the underlying mechanisms accounting for symptoms seen in autism is that a more general cognitive deficit may be present (Frith, 1989; Klinger & Dawson, 2001; Strauss, 2004). One such theory is weak central coherence (Frith, 1989).

Frith (1989) suggests the deficits found in autism result from a general cognitive disorder that impairs central coherence abilities. A perceptual processing deficit is present, which interferes with the ability to integrate diverse information, or abstract information, to obtain higher level meaning from contextual information. Weak central coherence has face validity. It mirrors the characteristic learning style observed in those with autism, which is attention to detail in the environment to the exclusion of overall understanding of context (Klin et al., 2002), and the inability to abstract. Empirical evidence supporting weak central coherence theory includes the finding that, unlike typically-developing children, those with autism do not demonstrate an increase in recall ability for words that are learned within a contextual framework (Hermelin & O'Connor, 1970; Tager-Flusberg, 1991). In addition, individuals with autism consistently outperform controls in tasks requiring focus on local level of detail, such as the embedded figures test and block design Wechsler subtest (Shah & Frith, 1983, 1993). Individuals with autism also fail to succumb to visual illusions (Happe, 1996), suggesting superior attention to detail at the featural level, without abstracting information from the entire perceptual stimulus.

As Klin et al (2002), however, points out, proponents of weak central coherence theory fail to focus on, or account for, the profound social deficits found in individuals with autism. Instead, weak central coherence theory focuses primarily on perceptual deficits, such as the inability to define the whole as a sum of the parts. So it seems that specific social theories of autism cannot explain general cognitive deficits, while cognitive theories of autism cannot adequately explain social deficits seen in autism. The purpose of the present document will be to argue that one such cognitive theory, weak central coherence, may provide explanatory power for social, as well as cognitive, deficits seen in autism.

According to the DSV-IV, the domain of social deficits is specific to autism and is an important part of the diagnostic criteria (American Psychiatric Association, 2000). Social deficits include failure to develop typical peer relationships, poor eye contact, failure to spontaneously seek to share enjoyment or interests, and failure to use appropriate emotional intonation or facial expressions. This is in contrast to the other two diagnostic domains, communication and restricted and repetitive behavior, which are found in other developmental disorders and in mental retardation syndromes (Schultz, 2005). Therefore, any theoretical perspective which adequately accounts for deficits seen in autism should focus on syndrome specific social dysfunction. Many early social impairments found in autism, such as deficits in joint attention, eye contact, attention to faces, and responding to emotional displays, involve the ability to process information from faces (Dawson, Webb, & McPartland, 2005).

One social impairment in individuals with autism, an impairment in face processing, has recently become the focus of much autism research. It is known that in typically developing infants, face processing abilities are present as early as the first weeks of life (Goren, Sarty, & Wu, 1975; Walton & Bower, 1993) and remain an important aspect of social interaction throughout life. Concerning autism, little is known about face processing abilities prior to school-age, but numerous studies have identified face processing deficits in older children and adults (e.g., Boucher & Lewis, 1992; Boucher, Lewis, & Collis, 1998; Gepner, de Gelder, & de Schonen, 1996; Klin et al. 1999; Klin et al. 2002; Langdell, 1978; Tantam, Monoghan, Nicholson, & Stirling, 1989).

A model that may extend the perceptual/contextual deficits explained by weak central coherence into the social realm of face perception has been proposed by Valentine (1991, 1999). Weak central coherence emphasizes that individuals with autism tend to focus on featural aspects of stimuli and fail to abstract knowledge to understand a contextual whole. Valentine has proposed a model of face perception abilities in typically developing adults which necessitates the ability to extend understanding beyond the featural level and abstract information to develop expertise with experience. Both Valentine's model, as well as current the face processing literature for both typical individuals and those with autism, will next be discussed within the context of three areas of face processing: (a) recognition and memory for faces; (b) gender discrimination; and (c) emotion recognition

1.1 RECOGNITION AND MEMORY OF FACES: VALENTINE'S FACE SPACE MODEL OF FACE PROCESSING

The role of experience and learning has been a primary area of focus in the adult face processing literature. Experience has been shown to be a very important factor in both face perception and recognition of faces. Valentine (1991, 1999) has proposed an experience-based face space framework that dominates the adult facial perception and recognition research. The face space can be conceptualized as a multiaxial, n-dimensional space representing all possible aspects of a face including both configural (e.g. distance from eyebrows to eyes) and featural (e.g. size of nose, color of eyes) information. In this framework, faces are stored according to the value of their features. The dimensions of the face-space framework depend upon an individual's experience with faces, although it is an inherent assumption of Valentine's theory that all of the feature distributions are normally distributed. Therefore the center of this framework represents the central tendency of all features. As an individual gains experience with faces, these faces are represented in the face-space framework according to the values of their features. With more experience, the distributions become more refined and the central tendencies become more accurate Faces with more typical features are stored closer to the center of the axes than faces containing distinctive features. Thus, with experience over time, the center of the face space, where typical facial-feature information is stored, becomes densely packed.

The periphery of the face space, where more distinctive (i.e. less typical) face information is stored remains less populated. With increasing distance from the center of the axes, stored facial representations become more distinctive and more easily recognizable because of less interference with other stored representations. For example, a caricatured face would be stored farther away from the center than a veridical face, and would therefore be more distinctive and easily recognizable. Research has provided support for the notion of this distinctiveness effect; adults are able to recognize and remember a caricature more accurately than the depiction of a familiar veridical representation of the same face (Rhodes, Brennan, & Carey, 1987). The development of a face-space framework depends on experience and implies knowledge of the range of feature values present and configural relationships of those features in the environment. Thus, Valentine's (1991, 1999) face-space model encompasses both featural and configural aspects of face processing.

1.2 FEATURAL AND CONFIGURAL PROCESSING

There is no clear consensus regarding the definition of the terms featural and configural in the face processing literature (Newell, 2004). For the purpose of the present document, featural processing refers to encoding and recognition of faces based upon one or more features, with no reference to the relationships among features. Configural processing refers to the encoding and recognition of faces with respect to the spatial relationship among the individual facial features (Schwarzer, 2000). Featural processing has been conceptualized as a less advanced manner of processing stimuli, while configural processing is thought to reflect more advanced processing. Controversy exists as to the extent to which featural versus configural information may be critical to performance (Cabeza & Kato, 2000; Hosie, Ellis, & Haig, 1998; Macho & Leder, 1998; Parks, Coss, & Coss, 1985; Rhodes, 1988; Suzuki & Cavanagh, 1995;

Tanaka & Sengco, 1997). A substantial amount of evidence exists, however, to suggest that adults show superior face processing abilities when faces are presented in an upright configuration (Yin, 1969). In addition, they rely primarily on configural processing when presented with upright faces, while relying more on featural processing when examining inverted faces (Bartlett & Searcy, 1993; Searcy & Bartlett, 1996). Furthermore, Ingvalson and Wegner (2005) have recently conducted a series of experiments showing that featural and configural information are processed independently of one another.

Research examining adult attention to high- versus low-spatial frequency information found in faces has provided additional evidence that while both types of processing are used in adult face perception, configural processing appears to dominate (Tanaka & Farah, 1993). Deruelle et al. (2004) explains that visual information is analyzed through a series of channels, which are attuned to different frequency ranges. High frequency ranges encompass featural information, while low frequency ranges contain configural information. Studies of face processing indicate that low spatial frequency information is processed more quickly, and used more frequently (e.g. Fiorentini, Maffei, & Sandini, 1983; Schyns & Oliva, 1999; Sergent, 1982). The distinction between featural and configural processing is an important one when examining the development of face perception skills.

1.3 TYPICAL DEVELOPMENT OF FACE PERCEPTION SKILLS FOR RECOGNITION AND MEMORY OF FACES

The primary focus of research addressing the development of face recognition and perception skills in infants and children has been on changes in processing strategies. For example, Diamond & Carey (1977, 1986) proposed a processing-shift hypothesis in which children primarily employ featural processing strategies until age 7-10 and then shift to a more advanced, configural processing style. Research indicates that with development, children slowly shift from a predominant reliance on processing more featural aspects of faces to having adult expertise at processing configural or spatial aspects of faces (Mondloch, Dobson, Parsons, & Maurer, 2004; Mondloch, Le Grand, & Maurer, 2002; Schwartzer, Huber, & Dummler, 2005).

Regardless of processing style, it is known that newborns are attracted to faces within hours of birth (Goren, Sarty, & Wu, 1975; Johnson & Morton, 1991) and will track facial stimuli further than other stimuli (Goren et al., 1975). Although a newborn cannot see fine details of faces, it appears that they can recognize their mother's face based upon head shape and outer contours of the face (Maurer, 1985). It is not until about one month later that an infant is able to recognize their mother based on the presence of features, in the absence of lower level perceptual cues such as head shape (de Haan, Johnson, Maurer, & Perrett, 2001; Pascalis, de Haan, Nelson, & de Schonen, 1998; Pascalis, de Schonen, Morton, Dereulle, & Fabre-Grenet, 1995).

Face knowledge continues to develop throughout childhood (Newell, 2004). Current research indicates that by the end of the first year infants are able to remember faces. They can also abstract prototypes (de Haan, et al. 2001; Strauss, 1979) and categorize gender (Newell & Strauss, in prep). Evidence suggesting that young infants process faces featurally rather than configurally comes from the inverted faces literature. Researchers have theorized that faces presented in an inverted orientation cannot be processed configurally, since inversion is thought to disrupt configural processing, and therefore are not remembered as well as upright faces. Faces presented in an inverted orientation require a more featural method of processing faces (Bartlett & Searcy, 1983). Young infants do not show the same advantage for upright faces as do adults, suggesting that the primary face processing method used by infants is featural (Cashon & Cohen, in press). It is not until five to six months of age that an advantage for upright faces is found. These data provide support for the hypothesis that by five to six months of age, infants are beginning to use at least some configural face processing strategies.

Despite advances in the understanding of the development of face processing skills, little is known about Valentine's face-space model (1991, 1999) regarding predictions about children's ability to process faces. Assuming the face space model is applicable to children, it is possible that distinctive faces would be easier to recognize and remember, and that performance would improve as experience with faces increased. This is precisely what has been shown in a series of experiments conducted by Strauss (2004), which showed that nine- to ten-month infants demonstrate no advantage for recognition of distinctive over typical faces. However, by three- to four-years of age, children are beginning to show a slight recognition advantage for distinctive vs. typical faces. The development of these skills, as evidenced by an emerging distinctiveness effect may be reflective of a growing face-space framework.

1.4 DEVELOPMENT OF FACE PROCESSING SKILLS FOR RECOGNITION AND MEMORY OF FACES IN INDVIDUALS WITH AUTISM

A growing body of literature suggests that most children and adults with autism have difficulty with both the perception of and memory for faces (Boucher & Lewis, 1992; Boucher, Lewis, & Collis, 1998; de Gelder, Vroomen & van der Heide, 1991; Ellis, Ellis, & Deb, 1994; Gepner, de Gelder, & de Schonen, 1996; Klin et al., 1999; Langdell, 1978). The recognition abilities of individuals with autism, however, are clearly above chance and a few studies have not found any facial recognition deficits (Hobson, Ouston, & Lee, 1988; Langdell, 1978). However, even studies that have found face recognition and memory deficits in those with autism have only found an average of 15% impairment, when compared with controls. Clearly, individuals with autism are able to process faces, and their performance is not completely impaired, such as is seen in other populations (e.g. prosopagnosia).

What, then, might account for the observed differences in face processing abilities? One possibility is that individuals with autism do not process configural information as efficiently as typically-developing children. This speculation is based on the finding that autistic individuals do not show the typical advantage for upright versus upside down faces (e.g., Hobson, Ouston, & Lee, 1988) and that they rely on peripheral details such as jewelry or clothing (e.g., Weeks and Hobson, 1987). In addition, data from several studies (Davies, Bishop, Manstead, & Tantam, 1994; Hobson et al. 1988) suggest that children with autism recognize schematic face stimuli or photographs of faces by relying on facial features only. Unfortunately, most of the studies examining face recognition and memory skills have not controlled for important issues such as whether the participants are being shown just facial information or peripheral information such as hair, clothing, or glasses.

There has been limited discussion of what underlying processes may be different as a result of autism. Some interesting possibilities have emerged from recent fMRI research. These studies (Critchley et al., 2000; Pierce, Muller, Ambrose, Allen, & Courchesne, 2001; Schultz et al., 2000) have shown that when individuals with autism process facial information, there is significantly less activation of the fusiform gyrus, particularly the fusiform face area (FFA), and more activation in areas used in processing objects. The FFA has been identified as an area of the brain which activates selectively when face stimuli is presented. Hypoactivation of the FFA, together with poorer performance in face processing tasks, suggests that individuals with autism process faces differently, and perhaps not as efficiently as typically developing individuals.

fMRI studies suggest that the facial discrimination and recognition deficits seen in individuals with autism may result from a lack of expertise with faces. Such expertise is required when individuals are forced to discriminate or remember subtle internal facial configurations versus more salient peripheral features such as hair style, jewelry, or clothing. As Elgar and Campbell (2001) suggest, this view fits with the developmental literature which indicates that during the course of development, children become better (or gain expertise) at distinguishing internal facial features and become less dependent on "paraphernalia". In contrast, individuals with autism may rely more than others on salient or distinctive features in order to discriminate and remember faces. While these features may be external to the face (e.g., facial hair, hair style, jewelry) it is possible that they can use internal features that are particularly distinctive or salient. For example, a very long nose or large forehead may be used for identification if they are particularly distinct.

More specifically, Pierce and colleagues (Pierce, Muller, Ambrose, Allen, & Courchesne, 2001) suggest that there may be a critical period for the development of the FFA. Research (e.g. Cohen & Strauss, 1978; Strauss, 1979; Lewis & Strauss, 1984) in the area of both face perception and concept development would indicate that this period occurs during infancy. It is possible that individuals may experience abnormal development during this critical period, affecting the development of the FFA and maybe even configural processing, in general. The same mechanisms that may account for face perception and recognition skills can be applied to another aspect of facial recognition: Gender identification.

1.5 TYPICAL DEVELOPMENT OF GENDER DISCRIMINATION SKILLS

Research indicates that adults demonstrate a very high rate of speed and accuracy when classifying gender of faces (O'Toole et al., 1998), particularly when the face has been rated as a typical representation of its gender (Newell, 2004). Gender discrimination is based upon the fine-grained discrimination of features (e.g., nose length, chin width, etc.) which are maximally distinctive between males and females (Brown & Perrett, 1993; Chronicle et al., 1995; Yamaguchi, Hirukawa, & Kanazawa, 1995). Not only are adults very good at classifying gender, they are also quicker to identify the gender of a face that has been rated as being very typical of its gender. For instance, a male face that has been rated by adults as being very masculine is classified as male in a gender identification task significantly faster than a male face that has been rated as being somewhat less masculine (O'Toole et al., 1998). This typicality effect may also be explained using Valentine's (1991, 1999) face space framework. Within the framework of Valentine's model, O'Toole et al. (1998) speculated that there may actually be two face-spaces, one for female and the other for male faces. Although distinctive faces (on the periphery of the face space) may be easier to recognize on subsequent exposures, they may be more difficult to initially classify, due to the fact that they deviate from the central tendency, or prototype, of their respective gender group.

Developmentally, little is known regarding the effects of typicality on the ability of infants or children to categorize facial gender based solely upon internal facial features. Recently, Newell, Strauss, & Best (2003) have examined the developmental trajectory of gender identification in a cross sectional study using infants aged five, six, eight, and eleven months, as well as three-, four-, and eight-year old children. In addition to determining at what age infants begin to discriminate gender, these studies were designed to investigate whether more typical representations of gender were classified more easily than less typical ones at various ages. If the face-space model is correct, more typical faces should be easier to identify on the basis of gender. Using a habituation paradigm, it was found that five-month old infants could not categorize the gender of faces, regardless of their typicality. By six months, however, infants were able to categorize gender, but only for typical faces.

At age three, 70% of participants were able to discriminate gender (without hair cues) in typical faces, and 58% were able to discriminate gender for atypical faces. By age four, 82% identified gender (without hair cues) in typical-gender stimuli and 69% identified gender in the atypical condition. However, by age eight, typically-developing children exhibited gender-identification abilities analogous to those of adults. Based upon the proposed deficit in face processing abilities in those with autism, results could be predicted to be quite different for individuals with this disorder.

1.6 DEVELOPMENT OF GENDER RECOGNITION SKILLS IN CHILDREN WITH AUTISM

Few studies have been conducted examining gender recognition abilities in individuals with autism. Several studies suggest that individuals with autism may have difficulty discriminating gender (de Gelder, Vroome, & van Der Heide, 1991; Hobson, 1987; Hobson, et al., 1988). Strauss (2004) found a developmental trend when examining gender identification abilities in 8 to 12-year old children with autism. Although high functioning children with autism showed improvement in gender recognition abilities from 8 to 12 years of age, they were still significantly worse than typically developing controls. At age 8, children with autism discriminated gender accurately in the typical condition at a rate of 94% (compared with 100% for controls) and 92% in the atypical condition (compared with 96% for controls). At age 12, autistic children discriminated gender accurately at a rate of 97% in the typical condition and 93% in the atypical condition. Although these rates were well above chance, they were significantly worse than typically-developing controls. More importantly, reaction time data revealed that while controls were considerably faster at identifying typical vs. atypical examples of gender, those with autism showed no reaction time differences between typical and atypical stimuli, suggesting the possible use of a different or compensatory process of gender identification. Although a developmental progression in the ability to correctly identify gender appears occur in children with autism, further research with children with autism younger than age eight should be conducted for a more complete developmental picture. The same mechanisms that may account for face perception skills such as gender identification and face recognition can be applied to another aspect of facial recognition: emotion recognition.

1.7 TYPICAL DEVELOPMENT OF EMOTION RECOGNITION

Infants are extremely sensitive to facial expression (Bornstein & Arterberry, 2003, Diamond & Carey, 1977; Nelson, 1987) and studies using either paired comparison or habituation paradigms have shown they are able to discriminate among some facial expressions (Barrera & Mauerer, 1981a; Field, Woodson, Greenberg, & Cohen, 1982; La Barbera, Izard, Vietze, & Parisi, 1976; Young-Browne, Rosenfeld, & Horowitz, 1977). Four-month olds can discriminate happiness vs. other emotions, as shown through habituation paradigms (Camras & Allison, 1985, Everhard, Shucard, & Schucard, 2001; Kuchuk, Vibbert, & Bornstein, 1986).

Other studies have not found facial expression discrimination abilities to be present until five to six months (Charlesworth & Kreutzer, 1973). Still other research reports that the ability to discriminate facial expression of emotions improves from the ages of four to seven months (Caron, Caron, & Myers 1982). However, research conducted by Ludemann & Nelson (1988) suggests that even at seven months, infants cannot categorize fear expressions and cannot discriminate fear from happy or surprise.

By the toddler years, children have been reliably shown to correctly identify sad, and happy more than any other expression (Izard, 1971). The ability to correctly discriminate emotions continues to develop throughout the preschool years (Boyatzis, Chazan, & Ting, 1993; Camras & Allison, 1985; Markham & Adams, 1992). Studies suggest that by the various ages of either five, seven (Tremblay, Kirouac, & Dore, 1987), or ten (Harrigan, 1984) no further change or improvement occurs (De Sonneville et al. 2002) in the ability to discriminate emotional expressions. Despite the equivocal evidence regarding when emotion recognition becomes fully developed, it has been established that by age six, basic emotions such as happy, mad, afraid, and sad seem to be fully developed, while more complex emotions such as surprise and shame continue to mature (Markham & Adams, 1992) until approximately age 7-10, when identification accuracy substantially increases. De Sonneville and colleagues (2002) suggest that one mechanism that may contribute to increased identification accuracy through infancy to age 10 is the development of configural processing strategies.

Increased ability to process face stimuli configurally, combined with the increased development of emotion-event prototypes (Shaver, Murdaya, & Fraley, 2001), through exposure and experience, may account for developing expertise. Given that it has been proposed that individuals with autism have deficits in both configural processing (Hobson et al., 1988; Weeks

& Hobson, 1987), as well as prototype formation (Klinger & Dawson, 2001; Plaisted, 2001), the presence of emotion recognition deficits in individuals with autism would not be surprising.

1.8 AUTISM: EMOTION RECOGNITION

From the time when autism was first identified (Kanner, 1943), emotional deficits have been a primary diagnostic criterion. Many studies have examined the ability of both children and adults with autism to recognize common categories of facial expression (e.g. Hobson, 1986; Weeks & Hobson, 1987; Hobson et al., 1988; Ozonoff, Pennington, & Rogers 1990; Capps, Yirmiya, & Sigman, 1992; Davies, Bishop, Manstead & Tantam, 1994; Gepner, Deruelle, & Grynfeltt, 2001). Despite this impressive body of literature, it remains unclear to what extent deficits in the ability to perceive facial expression contributes to the difficulties individuals with autism have regarding social interactions. In fact, it is still unclear whether individuals with autism truly have a deficit in recognizing emotional expression in faces. Some studies suggest the ability is intact (e.g Braverman, Fein, Lucci & Waterhouse, 1989; Davies, Bishop, Manstead, & Tantam, 1994; Gepner, Deruelle, & Grynfeltt, 2001; Ozonoff, Pennington, & Rogers, 1990), while others suggest it is impaired, relative to controls (Dawson, Meltzoff, Osterling & Rinaldi, 1993; Gepner, de Schonen, & Buttin, 1994; Hobson, 1986, 1986a; Hobson et al.,1988; Loveland et al. 1997; MacDonald et al. 1989; Sigman, Ungerer, Mundy, & Sherman, 1987; Teunisse & de Gelder, 2001). One possible reason for mixed results in autism emotion recognition research are methodological differences across studies. Studies have used different experimental procedures including sorting, matching, and identification. These methodological differences have led to several debates in the literature (e.g. Celani, Battacchi, & Arcidiacono, 1999). One of the reasons these methodological issues are important is because, with some matching tasks used, it may be possible for individuals with autism to use compensatory strategies by matching on a simple perceptual cue as opposed to a true recognition of facial expression (Celani et al, 1999). A similar concern was raised by Baron-Cohen, Spitz, & Cross (1993) in discussing the finding that individuals with autism were able to perceive both happy and sad expressions but not surprise. It may be that happy and sad are perceived by simple distinctive, differences in the mouth, whereas surprise may require more attention to the overall face, including the eyes. Attention to only one feature, such as the mouth, can be accomplished using simple featural processing, while simultaneous multiple-feature processing may require a more configural or holistic approach.

Another limitation of previous autism studies regarding interpretation of facial expression of emotion is that the stimuli used are almost always exaggerated expressions of emotion. It may be that featural cues are more salient in exaggerated expressions, allowing for successful task completion despite the use of a different process than that used by typically developing children. Finally, very few studies have attempted to use dynamic motion displays of emotional expression, and only one study has specifically compared the effect of dynamic versus static displays (Gepner, Deruelle, & Grynfeltt, 2001). This is surprising since, by definition, expressions are the result of muscle movement and are therefore dynamic in nature. Gepner and colleagues ascertained that while typical children found it easier to recognize emotional expression in the dynamic condition, children with autism did not. This suggests that children with autism may process facial expressions using different underlying processes. It might be that when dynamic stimuli of varying degrees of subtlety are presented to participants with autism, impairments may become more evident.

1.9 SUMMARY

In conclusion, as Nelson (2001) recently argued, there is much evidence to suggest that the perception and recognition of faces depends on a developing expertise with faces. Evidence from literature examining the typical development of face processing skills supports this notion. Valentine's (1991, 1999) model of face perception may extend the perceptual/contextual deficits explained by the weak central coherence theory of autism into the social realm. Valentine's model of typical development suggests that critical elements in face expertise develop over time with exposure to many faces. The dimensions of the face space framework depend upon an individual's experience with faces, although it is an inherent assumption of Valentine's theory that all of the feature distributions are normally distributed and so the center of this framework represents the central tendency of all features. In addition, information from both featural and configural aspects of faces are used to increase knowledge about faces. Research examining high and low frequency information contained in faces suggests that while configural and featural aspects of processing are important (Deruelle et al., 2004), by adulthood, configural information is primary in the ability to identify faces, at least in the upright position (Bartlett & Searcy, 1993; Searcy & Bartlet, 1996). It is unclear, however, how Valentine's model might apply to the development of face processing skills in autism, given the paucity of developmental information available relative to this disorder.

In the adult autism literature, controversy regarding face processing abilities exists, with some studies finding deficits in face processing skills such as identification of emotion (e.g., Hobson, 1986, 1986a, MacDonald et al., 1989) while others have not (e.g. Braverman, Fein, Lucci, & Waterhouse, 1989; Hobson et al., 1988). Although most autism studies have focused primarily on adults, some studies have examined skills in adolescence (Teunisse & de Gelder,

2001) and in children older than eight (Langdell, 1978; Strauss, 2004) Few studies, however, have examined younger children's face processing abilities. In terms of gender identification abilities, no studies have examined these skills in children with autism who are younger than eight. This is in stark contrast to the available literature on the typical development of face processing skills, in which literature exists from early infancy to adulthood. Obviously, it would be impractical to attempt to study face processing abilities in those with autism during infancy, since diagnosis cannot reliability be made until 18-24 months, although research is being conducted to ascertain if autism can reliably be diagnosed as early as15 to 18 months (Filipek et al., 1999). The purpose of the present study was to examine face processing skills in the youngest verbal population of children with autism in which testing is deemed to be practical. Since a language delay is one of the primary diagnostic criteria of autism, it was determined that age five would be an appropriate age at which it might be expected that high functioning children with autism would have, at least, rudimentary receptive and expressive conversational skills.

In the current study, three aspects of face processing were examined: recognition memory, gender identification, and identification of emotional expression. These face processing skills were examined in five- to seven-year-old children with autism and controls matched on verbal mental age and chronological age. The age group of five to seven was chosen because no previous studies have examined all three of these aspects of face processing in this age group.

2.0 EXPERIMENT ONE: RECOGNITION MEMORY

According to Valentine's face space model, distinctive faces are more easily identified and remembered. This distinctiveness effect occurs because distinctive faces are stored on the periphery of the face space, where less information is stored. The center of the face space framework, where information regarding more typical (less distinctive) faces is stored, is thought to be densely packed. Distinctive faces, which are stored in the less densely populated periphery, are more easily accessible to memory. Recall that Valentine's model suggests that expertise is gained by experience and through abstraction of information regarding both configural and featural aspects of faces. Thus, in order to demonstrate the distinctiveness effect, individuals need to learn how critical facial features are varying (e.g., eye separation, nose length, etc.) and ultimately abstract the mean value of these variations. It is assumed that the values of these features are normally distributed and that distinctive features represent the "tails" of the distribution. While there is limited research exploring how early typically developing children demonstrate this distinctiveness effect, there is reason to believe that it begins in infancy (Newell, Strauss, & Best, 2003). Therefore, typically developing children are expected to remember distinctive faces better than more typical or common faces. There is reason to believe that this memory advantage for distinctive faces will not be demonstrated in children with autism. First, they may have less experience with faces. Second, based on previous research, they may not be able to abstract prototypic representations of the feature variations. Finally, based on the weak central coherence theory, they may not be able to abstract configural information. An implicit memory task was chosen because all prior studies examining recognition memory abilities in individuals with autism have used explicit memory procedures where participants were told they would be asked to remember the faces they observed.

2.1 METHOD

2.1.1 Participants

Participants consisted of 19 children who were previously diagnosed with High Functioning Autism (HFA) by various psychologists in the community. HFA is defined by a significant impairment in all three areas of the DSM-IV diagnostic triad of social, behavioral, and communicative, deficits (American Psychiatric Association, 2000) without co-occurring mental retardation. High functioning children were chosen for this study because this allows for the examination of impairments that are specifically associated with autism rather than with mental retardation (Minshew, Goldstein, & Siegel, 1997). The age range of five to seven was chosen in order to fill a gap in the literature; no face processing data exists regarding children in this age group. Diagnosis of HFA was confirmed by administration of the Autism Diagnostic Observation Schedule – Generic (ADOS-G; Lord et al., 2000), a conversation interview administered directly to the participant. The staff administering the ADOS-G had extensive clinical experience with autism and completed a week-long training and reliability course held by the first author of the ADOS-G. Eighteen control participants were matched on chronological and a standard score equivalent of Verbal Mental Age (VMA). A standard score equivalent of VMA was obtained using the Peabody Picture Vocabulary Test – Revised (PPVT-R; Dunn &

Dunn, 1981), an instrument that has demonstrated adequate validity and reliability. Controls were recruited by telephone solicitation using names purchased from a company that provides such information. No significant differences were found between groups in terms of chronological age and VMA (see Table 1).

Table 1. Sociodemographic characteristics of autism and control groups for all 3 experiments

	Autism Group (N=19)			Control Group (N=18)		
	M	SD	Range	M	SD	Range
Age (in months)	76.58	(9.45)	60 – 92	72.00	(9.65)	61 – 92
VMA	97.89	(15.86)	75 – 126	105.61	(11.99)	76 – 124
Gender (M:F)	14:5			11:7		
Ethnicity	19 Caucasian			18 Caucasian		

2.1.2 Apparatus

Each participant was seated in front of a 17-inch monitor controlled by a Dell laptop computer. The laptop computer was facing the examiner and the 17-inch monitor faced the participant. A second keyboard to be used by the participant was attached to the laptop computer, and a modified keyboard was placed over this keyboard. The modified keyboard, which is commercially available for young children, had two large keys (approximately 2.54 cm. square) exposed. The remainder of the modified keyboard was covered with black felt to inhibit distraction. The two exposed response keys were labeled “yes” and “no”, and the position (left/right) of the “yes” and “no” labels was counterbalance across participants.

2.1.3 Stimulus Materials

The stimuli were digital color photographs of women’s faces (age = 18-30 years). Stimuli volunteers were required to remove any jewelry and wear a common black robe to hide their clothing. In addition they were required to pull back their hair and wear a backwards black baseball cap. All volunteers were then photographed on a black background. Thus, all stimuli differed only on internal facial features. An initial group of 71 photographs were rated by approximately 60 undergraduate students for distinctiveness on a 7 point scale, with 1 being very typical and 7 being very distinctive.

Participants were given the following instructions: “ Imagine that you are in a crowd or at a party. As you view people at the party, it is apparent that some people’s faces are much more distinctive, such as Jay Leno’s face, which would stand out due to his larger jaw area. In contrast, a face such as a fashion model’s would be harder to remember (and distinguish from other fashion models' faces) because of the regularity of all features. Please note that distinctiveness and attractiveness are not the same. A fashion model's face is very attractive, in part because of the regularity and average quality of all features. Your job is to rate the following faces on a 7 point scale with 1 being very typical (like a model's face) and 7 being very distinctive (like Jay Leno). Based upon these ratings, three groups of stimuli were formed, faces that were rated most "distinctive" ($M = 4.34$, $SD = .27$), most "typical:"($M = 2.95$, $SD = .25$), and the faces that were rated in between the two groups, to be referred to as "neutral" ($M = 3.60$, $SD = .21$) in their distinctiveness. Of these stimuli, six of the distinctive ($M = 4.32$, $SD = .25$), six of the typical ($M = 2.28$, $SD = .23$), and twelve of the neutral ($M = 3.36$, $SD = .15$) faces were chosen for test stimuli. A t-test indicated that the distinctive faces were rated as significantly different than the typical faces, $t(10) = -14.62$, $p \leq .001$.

2.1.4 Procedure

Participants were individually tested in a quiet room, either at home or in the laboratory. They sat in front of the computer monitor and were told that they were going to hear a story about a girl's softball team who take a bus trip together. Then participants were told that help was needed with the story and were given a "magic wand" with which to help. First, they were shown a cartoon picture of a suitcase (either red or blue) and told that the team's lunches were on the suitcase and needed to be placed on the bus. They were told to touch the suitcase with the magic wand to place it on the bus. When the participant touched the suitcase with the magic wand, the examiner surreptitiously pressed a key on the laptop, changing the frame. The next frame the participant saw was the same suitcase, except that it was now on the bus rather than outside of bus. Thus, participants thought that their magic wand accomplished this task.

They were then shown a picture that had one of six possible softball team members in front of a picture of a school bus. Participants were told that the friends look very similar to each other (because they all like to wear black baseball caps backwards) but are actually different people if you look at their faces. Next, the participants were asked to help load the team members onto the bus by touching each team member on the nose with their magic wand. As with the suitcase, the participants then saw each team member on the bus in the next frame. Seeing each team member both in front of the bus and then on the bus allowed for further examination of each face stimulus. The procedure was repeated until all six team members were placed on the bus. Each time the participant put a new team member on the bus, they were also exposed to the faces of all previous team members who were already placed on the bus. Three of these team members were faces that adults previously rated as distinctive and three were previously rated as typical.

In order to create a memory delay period, the children were then told a story about how the bus visited various places such as the ocean, mountains, zoo, etc. At each stop on the field trip, the participants were told a brief story about the location. The memory delay portion of the task lasted approximately three and one half minutes. The last stop on the field trip was the zoo, where participants were shown a picture of a puzzled-looking driver standing next to the bus. They were told that it was time for the team members to go home and that the driver needed to get them back on the bus, but he could not remember who they were among all the other people at the zoo. The participants were told that the bus driver needed help identifying the team members. Before identifying the team member, the participants were shown pictures of the red and blue suitcases and were asked to show which one had carried the team's lunches by touching it with the magic wand. This was to ensure that task demands were understood.

Participants were then shown a face (either previously seen or not) and were asked to press "yes" if they had seen the team member before and "no" if they had not. Faces were shown in random order with six previously seen (distinctive or typical) faces and twelve neutral faces presented to each participant. The start of each trial was controlled by the experimenter who made sure that the child's attention was focused on the screen. Once a trial started, the child saw a face, which remained on the screen until the child responded by pushing the "yes" or "no" keyboard button. This procedure was repeated until all stimuli were presented.

2.2 RESULTS

Several participants with autism expressed that they could not tell the difference between the previously seen and "new" team member faces and thus pressed the same key (either "yes" or "no") each time a response was required during the task. Therefore, in order to avoid inflated false alarm rates, percentage of agreement scores were not used for data analysis. Instead, d prime (d') scores were calculated. D prime is a statistical measure of sensitivity which takes into account both *hits* (proportion of "yes" trials to which the subject responded "yes", and *false alarm* rates (the proportion of "no" trials to which the subject responded "yes"). As shown in Figure 1, a significant recognition memory difference was found for controls when comparing typical (M = .27, SD = .68) versus distinctive faces (M = .64, SD = 1.03), $t(17) = 2.65$, $p \leq .01$ (one tailed). For participants with autism, no difference was found when comparing responses to typical (M = .52, SD = 1.54) versus distinctive faces (M = .50, SD = 2.09), t(18) – 1.05, p = 1.5 (one tailed).

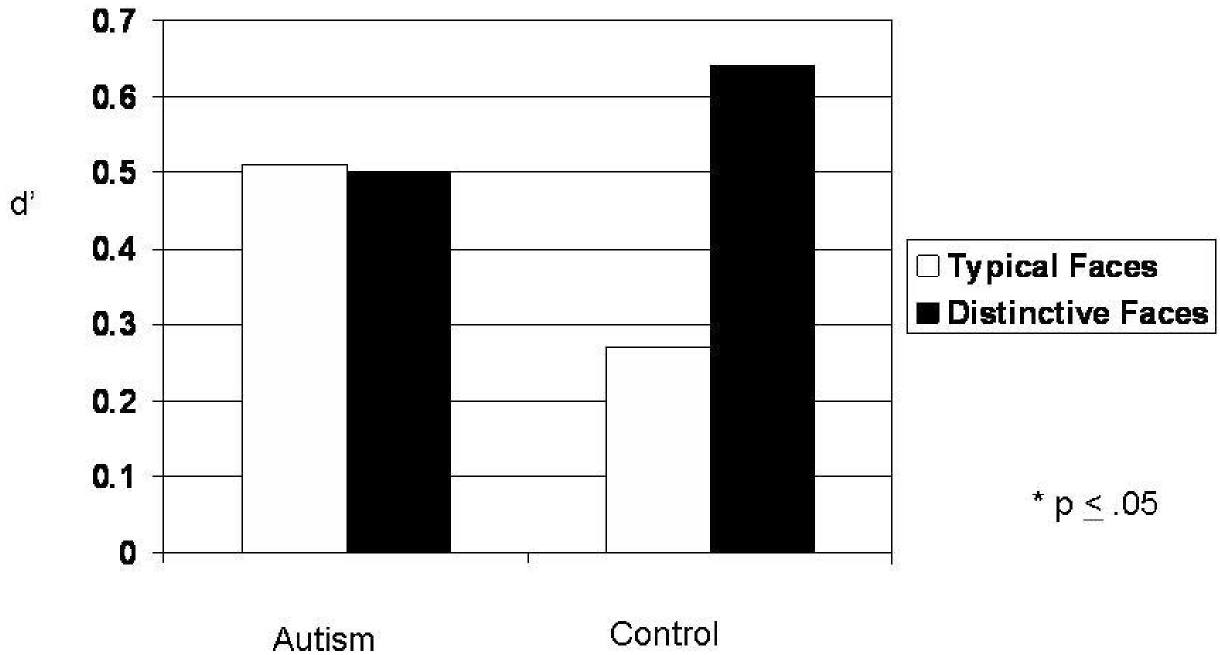

Figure 1. Differences in ability to remember typical and distinctive faces in children with autism versus controls.

2.3 DISCUSSION

Results are consistent with the hypothesis that children with autism would not show a distinctiveness effect, as evidenced by the lack of a significant difference between identification of typical versus distinctive faces. Control participants, on the other hand, did show a distinctiveness effect, as shown by results indicating that they remembered distinctive faces with greater accuracy than typical faces. These results provide support for the presence of a face processing deficit in recognition memory for children with autism by the ages of five to seven. It may be that, as Valentine's model suggests, expertise is gained by experience, and through abstraction of information regarding both configural and featural aspects of faces. Thus, results are consistent with weak central coherence theory, which suggests that children with autism have deficits in both processing configural information and abstracting knowledge.

3.0 EXPERIMENT TWO: GENDER IDENTIFICATION

Previous research indicates that adults are faster at classifying the gender of a face that is typical of its gender. This is also explained by Valentine's model. Within the framework of Valentines model, O'Toole et al (1998) has hypothesized that that there may be two face space networks, once for male and one for female faces. Although distinctive faces may be easier to recognize on subsequent exposures, they may be more difficult to classify initially, in terms of gender, due to the fact that they deviate from the central tendency, or prototype, of their respective gender group. Given deficits defined in Weak Central Coherence theory in children with autism, as well as their difficulty extracting prototypes (Klinger & Dawson, 2001), it is expected that children with autism will be impaired, compared with controls, in the ability to identify the gender of faces rated as less typical representations of gender

3.1 METHODS

3.1.1 Participants

The same group of experimental (*n* = 19) and control (*n*=18) participants used in Experiment 1 will be used for Experiment 2.

3.1.2 Apparatus

Each participant was seated in from of a 17-inch monitor controlled by a Dell laptop computer. The laptop computer was facing the examiner and the 17-inch monitor faced the participant. An additional keyboard was also attached to the laptop computer, and a modified keyboard was placed over the additional keyboard. The modified keyboard, which is commercially available for young children, had two large keys (approximately 2.54 cm. square) exposed. The remainder of the modified keyboard was covered with black felt to inhibit distraction. The two exposed response keys were on the left and right side of the modified keyboard (corresponding to the "x" and "m" keys), and were covered with the iconic representations of a man on one key and a woman on the other, which could be removed to counterbalance left and right hand responses across participants.

3.1.3 Stimulus Materials

Approximately 80 digital videos were made of males and females ranging in age from 18-30. The videos were taken with a digital camcorder and downloaded into a computer. Stimuli volunteers were required to wear a common black robe to hide their clothing. Volunteers were filmed with both their natural hair styles and with their hair hidden. To hide their hair, they wore a basic black baseball cap backwards, with the hair drawn to the back. When the videos were taken, they were framed so that just the face and a minimal amount of border were included on the video. The volunteers were seated in front of a black curtain, which blended with the cap and robe. With the robe, the cap, and the background all the same color, the videos provided a very dynamic display of just the face. In order to elicit a natural pose from the volunteers and to make the video as realistic as possible, volunteers recited a common nursery rhyme (Hickory, Dickory, Dock) during filming. Twenty undergraduate students rated each of the 80 videos for typicality of gender on a 7-point Likert scale, with 1 being very atypical of gender and 7 being very typical of gender (i.e., very masculine or very feminine). The 12 most typical female videos (*M* = 4.45, *SD* = .42), the 12 most typical male videos (*M* = 4.73, *SD* = .22), the 12 least typical female videos (*M* = 2.45, *SD* = 0.39) and the 12 least typical male videos (*M* = 3.48, *SD* = .33) were selected. The least typical faces were then presented to a second group of undergraduate students who were asked to determine the gender of each face to ensure that all of the faces were easily discriminable by adults. t-tests indicated that the ratings for the typical and atypical faces were significantly different from each other, for both the male $t(23) = 10.03$, $p \leq .001$ and the female $t(23) = 11.44$, $p \leq .001$ videos.

3.1.4 Procedure

Participants were individually tested in a quiet room, either at home or in the laboratory In order to insure that the participants could understand the task, they were initially shown ten full body pictures of both genders in random order and asked to say whether the picture was of a "man" or a "woman" ("boy" and "girl" labels were also acceptable). If the participant got all ten correct, they proceeded to the test phase. It was explained to the participant that he or she would see a very short movie of a person talking, although they would not be able to hear what the person was saying because the sound was turned off. Participants were told that their job in this game was to guess whether the talking person was a man or woman and to respond by pressing one of the two keys that were covered with pictures of a boy and a girl. Before the test trials were started, participants were asked to demonstrate what button they would press if they saw a movie was of a man (or a woman). Once they successfully demonstrated that they understood they were to push the "man" button for a male movie and the female button for a female movie, the test trials began. While it was initially planned to record reaction time data, it became apparent that many of the children would respond verbally before they actually pressed the response button, despite being told not to do so. Hence, reaction time data were not accurate and were not analyzed.

Participants were shown a total of 40 videos with equal numbers of male and female faces, typical and atypical faces, and videos with and without hair cues in randomized order. The start of each trial was controlled by the experimenter who made sure that the child's attention was focused on the screen Once a trial started, the child saw a video of a "talking" male or female stimulus, which remained on the screen until the child responded by pushing the "male" or "female" keyboard button.

3.2 RESULTS

Of primary interest was whether there were any accuracy differences (as measured by the proportion of correct answers) between the control and the experimental participants, and whether the children's accuracy was affected by either the typicality of the stimuli or the availability of hair as a feature. Thus a 2-way ANOVA was conducted that included Group (autism vs. control) as a between-subjects variable and Stimulus Type (typical with hair vs. typical without hair vs. atypical with hair vs. atypical without hair) as a within-subjects variable. Results indicated significant main effects for both Group and Stimulus Type, but more importantly a significant interaction between these two variables, $F\ (3,105) = 2.70$, $p < .05$. As shown in Figure 2, for the typical gender faces, the control participants were better at discriminating gender than were the participants with autism. This was true both for when the hair cues were present, t (35) = -2.87, p $\leq$ .01, and when hair was not present as a cue, t (35) = -2.82, p $\leq$ .01. In contrast, there were no differences between the groups in either of the conditions that used atypical gender stimuli.

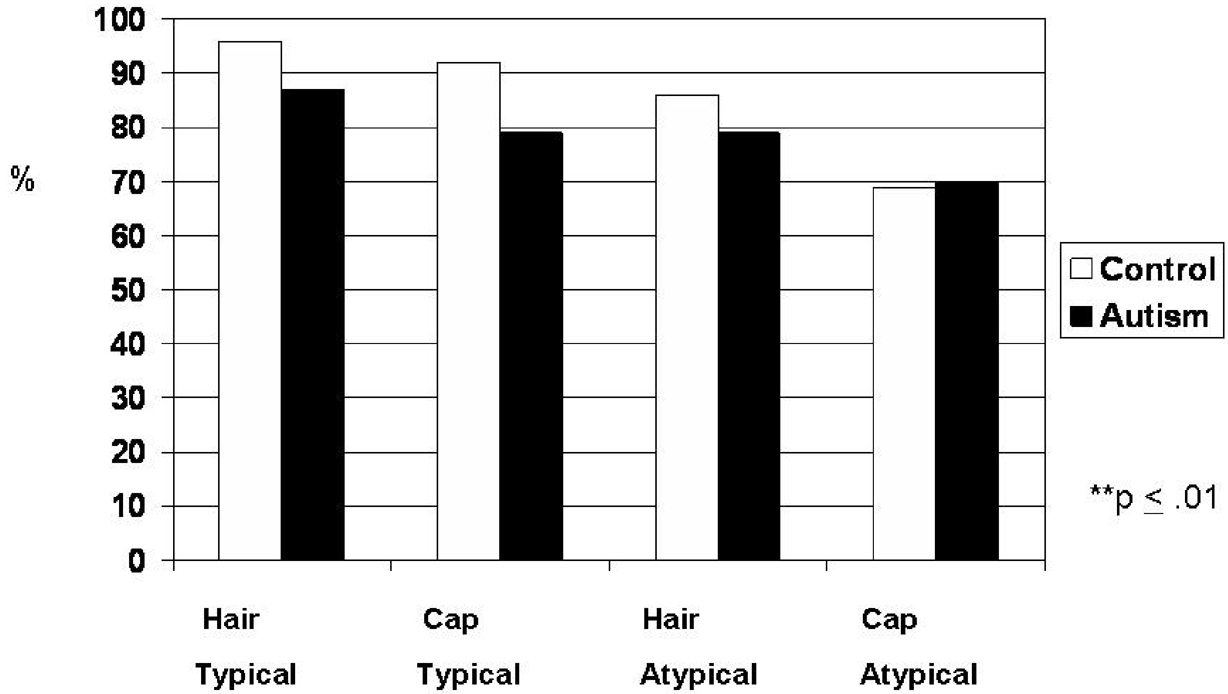

Figure 2. Differences in the ability to recognize both typical and atypical representations of gender in children with autism versus controls.

Hair cues also had an impact on the participants' ability to discriminate gender. The participants with autism were better at discriminating gender when hair cues were present in both the typical, t (18) = 2.70, p $\leq$ .05, and atypical t (18) = 2.32, $p < .03$ stimulus conditions. While the hair cues helped the control participants discriminate the atypical gender stimuli, t (17) =

4.12, $p \leq .01$, it did not affect their discriminations of typical gender faces, $t\ (17) = 1.80$, $p > .05$, which were approaching ceiling performance in both the hair and cap conditions.

3.3 DISCUSSION

The results of this study indicate that as early as five to seven years of age, children with autism are less able to discriminate the gender of faces even with very realistic videos of the people. This effect was only true with the typical faces, where the control participants were above ninety percent accuracy rate. While the participants with autism were not poor at discriminating the typical faces, their performance did not match that of the controls. Interestingly, both the control and autism participants were considerably worse at discriminating the atypical faces. Research by Strauss (2004) provides support for a growing face space framework between the ages of five to twelve. By the age of 12, both children with autism and typically developing children showed an increase in the ability to classify the gender of atypical faces, and children with autism showed a relative impairment in accuracy (92% accuracy versus 96% accuracy for controls). In the present study, the relatively poor performance of both groups in classifying gender when stimuli were atypical may be indicative of an immature face space framework, with less experience of atypical examples of gender, as compared to typical examples of gender.

4.0 EXPERIMENT THREE: IDENTIFICATION OF EXPRESSION OF EMOTION

Children with autism have been shown to exhibit impairment in the ability to process configural information. Because recognition of expressions of emotion, particularly more subtle expressions, requires configural processing strategies, it is expected that children with autism will be impaired, relative to controls, in the identification of subtle facial expressions of emotions, although they may be able to identify exaggerated emotional expressions in a manner analogous to typical controls. This potential ability to identify exaggerated expressions may be due to the fact that when exaggeration occurs, it is easier to focus on individual features of the face to extract emotion information.

4.1 METHOD

4.1.1 Participants

The same group of experimental (n = 19) and control (n=18) participants used in Experiments 1 and 2 were included in Experiment 3.

4.1.2 Apparatus

Each participant was seated in from of a 17-inch monitor controlled by a Dell laptop computer. The laptop computer was facing the examiner and the 17-inch monitor faced the participant.

4.1.3 Stimilus Materials

Approximately 60 digital videos were made of males and females ranging in age from 18-30 years. The volunteers all wore a black robe to hide clothing and a backwards black baseball cap with their hair tied back. The videos were taken with a digital camcorder and downloaded into a computer. Volunteers were filmed in front of a black background so that the videos provided a dynamic display of just the faces. Each volunteer was instructed to model the facial expressions of "happy", "sad", "anger", and "fear." All videos were viewed by students in the laboratory and the two best examples of each emotion were chosen by consensus. One student making the consensus ratings had previous experience and training in the Facial Action Coding System (Ekman & Friesen, 1975).

By consensus, the videos were edited so that they progressed from similar neutral expressions to an exaggerated pose of each expression. This was accomplished by careful examination of the videos in a frame-by-frame fashion. Following this editing, each video was then divided into six film clips, with the end point of each clip exhibiting a slight but progressive increase from the last clip in the movement of appropriate facial muscles necessary to model the respective emotion. Careful and repeated screening insured that the amount of increase in the movement of facial muscles required to pose an emotion was similar across all stimuli at each cut. For example, cut number four for all emotion stimuli had approximately the same muscle change from neutral for the appropriate emotion.

Following this procedure, digital videos were then made for each of the six clips per emotion, with the starting point of each video always set at the neutral pose. Prior to the beginning of each clip, a black screen with a yellow “ball” of approximately one inch in diameter was shown on the screen. This was done to provide a fixation point to ensure that attention was focused on the center of the screen prior to viewing each clip. Each successive clip of an emotion ended at the next higher level of expression of emotion, as evidenced by increased movement of facial muscles. After final editing of videos, a coder trained in Ekman & Friesen’s (1975) Facial Action Coding System reviewed all videos. The speed of each video was modified so that while they still appeared natural, all six clips of each emotion were presented to the participant for the same amount of time. For example, each clip level of the emotion was presented for approximately two seconds even though the amount of information conveyed via movement of facial muscles increased for each clip of the video. The speed was then standardized across all of the videos so that no exposure-time advantage would occur.

Undergraduate students ($N = 29$) were used for standardization trials of the emotion clips. After viewing each two-second clip, the screen went blank, and participants were then asked to identify the appropriate emotion. In addition, they were asked to indicate how confident they were of their judgment on a seven point Likert scale, with one indicating a “guess” response, and seven indicated a “sure” response. The clips were presented from the most difficult (i.e. least muscle movement) to the least difficult (i.e., most muscle movement). After reviewing results of the pilot study, it was decided to eliminate the first two clips of each emotion due to difficulty in identification. Therefore, four clips of each emotion remained. Pilot ratings indicated that by

Level III (out of IV) of each emotion video, the majority of participants were able to make an accurate identification. See Table 2 for accuracy percentages and "confidence in decision" ratings.

Table 2. Pilot Group Ratings of Emotion Stimuli

Emotion	Percentage Correct	Confidence in Rating	
Stimulus Level		M_a	(SD)
Sad			
Level 1	6.9%	2.79_a	(1.24)
Level 2	37.9%	3.21_a	(1.24)
Level 3	65.5%	3.48_a	(1.18)
Level 4	69%	4.59_a	(.63)
Angry			
Level 1	3.4%	2.97_a	(.91)
Level 2	31.0%	3.48_a	(1.15)
Level 3	51.7%	3.35_a	(1.17)
Level 4	79.3%	4.24_a	(.91)
Fear			
Level 1	17.2%	2.79_a	(1.11)
Level 2	65.5%	3.79_a	(1.08)
Level 3	93.1%	4.41_a	(.63)
Level 4	82.8%	4.58_a	(.63)
Happy			
Level 1	86.2%	3.79_a	(1.01)
Level 2	93.1%	3.79_a	(1.21)
Level 3	86.2%	4.48_a	(.91)
Level 4	100%	4.86_a	(.52)

[a] "Confidence in own rating" scale was a 7 point Likert Scale with 1 = "just guessing" to 7 = "completely sure"

4.1.4 Procedure

Participants were individually tested in a quiet room, either at home or in the laboratory, and were seated in front of a computer 17-inch monitor screen attached to a laptop computer. In order to ensure that participants could accurately identify the facial expressions of happy, sad, anger, and fear, a pretest was given using 12 stimuli (three of each emotion) from the McArthur Emotion Display set. All participants accurately identified 100% of the pretest stimuli. Following pretest, participants were given the following instructions prior to the test phase. "This is a game where you are going to look at people's faces and try to guess what they are feeling. You are going to see movies of people's faces, and your job is to tell me how that person is feeling. First you are going to see a yellow ball on the screen and you need to look at the ball very closely, because the movies are going to be really fast…like this (snap fingers), and then you won't see them anymore. For each face you can choose from these (present iconic faces): "happy", "sad", "anger", "fear", or "none." OK? Let's practice first. In some of the movies it will be easy to tell what the person is feeling, like this one (present sample "happy" clip, at level IV), and some of them are going to be hard, like this one (present sample "happy" clip at level I). Ready to start?"

Participants were then shown the level I video clips of each emotion in randomized order. After all level I clips were seen, each of the successive levels were shown, with randomization within each level. After the (approximately) two second presentation of a clip, the screen went blank. At that point, participants were asked to identify the emotion they thought they saw on the clip. They were presented with an array of iconic representations (i.e. "smiley faces") of "happy", "sad", "anger", "fear", or "no emotion."

4.2 RESULTS

A series of chi-square tests were used to analyze results of the emotion recognition task. Table 3 presents the number of respondents answering correctly for each emotion and level of stimuli.

Table 3. Recognition of Emotion: Number of participants who responded correctly at each level

Emotion	Stimulus Level	Number of Participants Who Responded correctly at each level	
		Autism (n=19)	Control (n=18)
Sad			
	Level 1	2	1
	Level 2	4**	10**
	Level 3	14	13
	Level 4	17	16
Angry			
	Level 1	0	1
	Level 2	2	5
	Level 3	6***	13***
	Level 4	14	16
Fear			
	Level 1	0	0
	Level 2	0***	7***
	Level 3	8***	16***
	Level 4	12**	17**
Happy			
	Level 1	6	7
	Level 2	13*	16*
	Level 3	17	18
	Level 4	19	18

*$p = .1$; **$p \leq .05$; ***$p \leq .01$

Results indicated that control participants were significantly better than participants with autism at recognizing featural cues of “sad” at level II, χ^2 (1, N = 37) = 4.69, $p \leq .05$ (see Figure 3). No significant differences were found for “sad” level I, χ^2 (1, N = 37) = .31, p = .58; level III, χ^2 (1, N = 37) = .01, p = .92; or level IV, χ^2 (1, N = 37) = .003, p = .95.

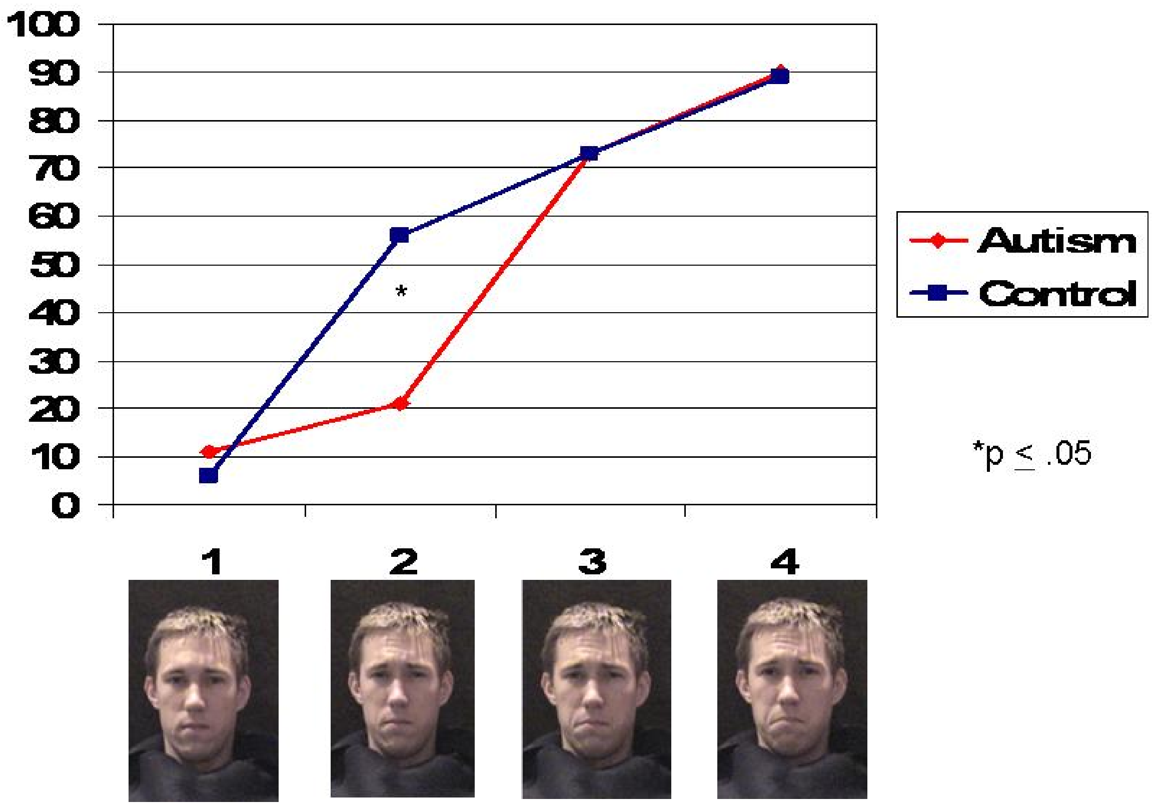

Figure 3. Differences in ability to recognize facial expression of the emotion “sad” between participants with autism and controls.

Control participants were significantly better than participants with autism at recognizing featural cues of "angry" at level III, χ^2 (1, N=37) = 6.11, $p \leq .01$ (see Figure 4). No significant differences were found for "angry" level I, χ^2 (1, N = 37) = 1.08, p = .29; level II, χ^2 (1, N = 37) = 1.79, p = .18; or level IV, χ^2 (1, N = 37) = 1.39, p = .24.

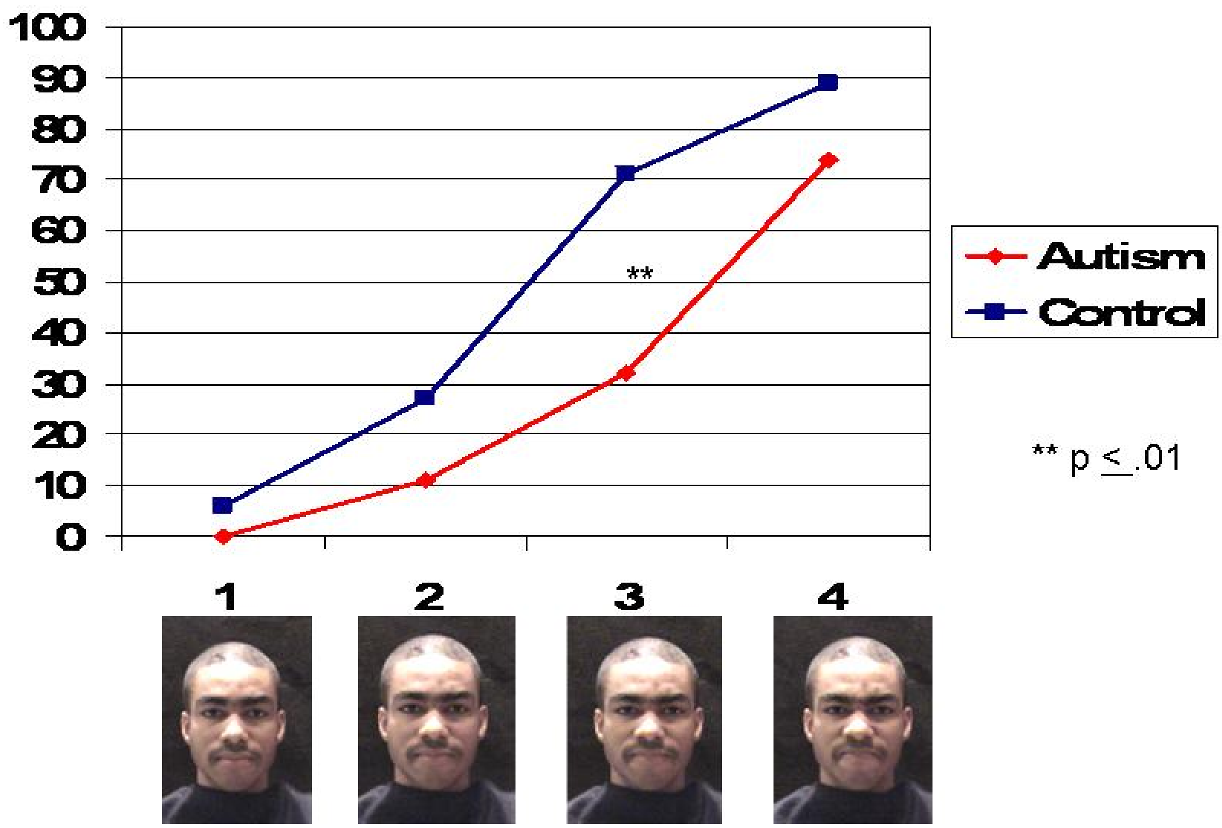

Figure 4. Differences in ability to recognize facial expression of the emotion "angry" between participants with autism and controls.

Control participants were significantly better than participants with autism at recognizing featural cues of "fear" at level II, χ^2 (1, N = 37) = 9.11, $p \leq .01$, level III, χ^2 (1, N = 37) = 8.88, $p \leq .01$, and level IV, χ^2 (1, N = 37) = 5.34, $p \leq .05$ (See Figure 5). No significant differences were found for "fear" level I. A chi-square could not be computed for "fear" level I because neither the control participants nor the participants with autism correctly identified the face stimuli at this level.

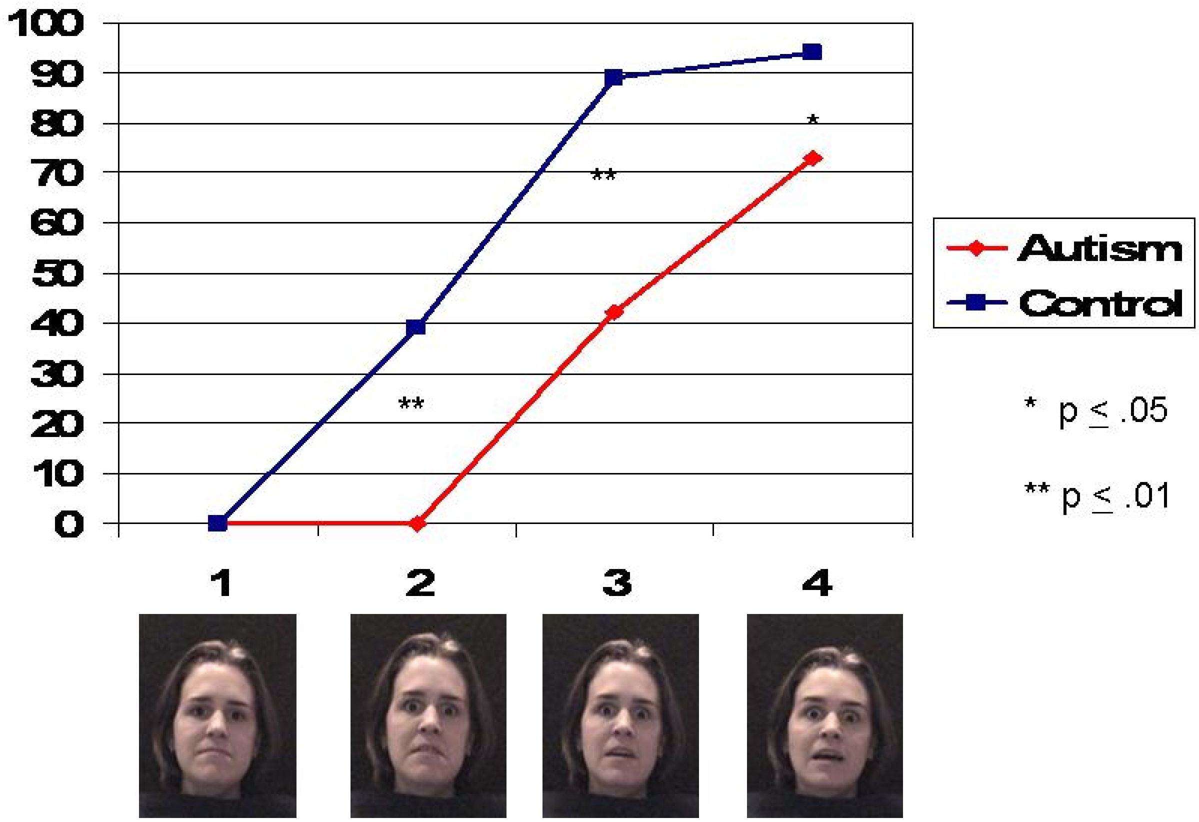

Figure 5. Differences in ability to recognize facial expression of the emotion "afraid" between participants with autism and controls.

For the "happy" condition, a trend was observed in which controls were better at recognizing featural cues for this emotion at level II, χ^2 (1, N = 37) = 2.29, p = .1 (See Figure 6). No significant differences were found for "happy" at level I, χ^2 (1, N = 37) = .22, p = .64; level III, χ^2 (1, N = 37) = 2.00, p = .16. A chi-square could not be computed for "happy" level IV because all of the control participants and participants with autism correctly identified the face stimuli at this level.

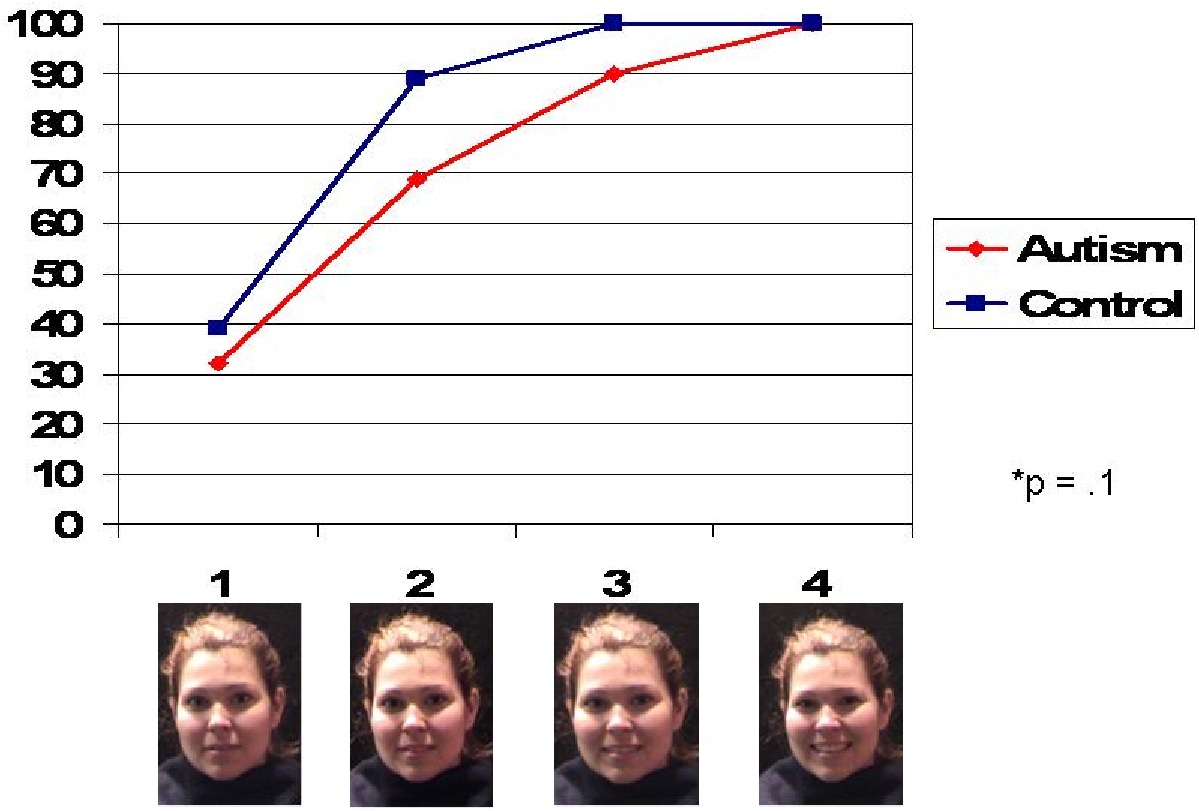

Figure 6. Differences in ability to recognize facial expression of the emotion "happy" between participants with autism and controls.

4.3 DISCUSSION

Typically-developing children were able to correctly identify "sad", "anger", and "fear" stimuli at one level of subtlety earlier than children with autism. For "happy" stimuli, a trend was observed in which typically developing children were able to identify this emotion at one level of subtlety earlier than children with autism. By level IV, when the expression of each emotion was presented in an exaggerated manner, participants with autism were able to identify each expression as accurately as the control children for all emotions except for "fear."

Differences in performance between groups of participants may have occurred due to a configural processing deficit thought to be present in autism. By level IV, performance became statistically equivalent in three out of four emotions (“happy”, “sad”, and “angry”), and this demonstrated ability of participants with autism to identify exaggerated expression as well as control children may have occurred because when exaggeration occurs, it becomes easier to focus on individual facial features to extract emotion information. More subtle expressions, on the other hand, require attention to, and integration of, smaller cues. For one emotion, “happy”, no significant differences were found between groups, and by level IV, both groups were at ceiling (100% accuracy). This result may have occurred because “happy” is easier to identify using only one feature, the mouth, as compared with the other three emotions in this experiment, which require integration of information from both the mouth and the eyes.

5.0 GENERAL DISCUSSION

Results of the current study indicate that compared to typically developing children, five to seven year-old children with autism experience deficits in three areas of face processing, recognition memory, identification of gender, and emotion recognition. In particular, children with autism had poorer recognition memory than control children and did not demonstrate any advantage for remembering distinctive faces. On the gender discrimination task, the children with autism were less accurate than control children in classifying faces when the stimuli were typical representations of each gender. For the less typical faces, both groups demonstrated difficulty in identifying gender correctly. For the emotion recognition task, typical children were able to correctly identify the emotions of “sad”, “angry”, and “fear” at one level of subtlety of expression sooner than children with autism. A similar trend was observed for the emotion “happy”, although both groups found this emotion easier to identify at all levels of subtlety.

Since the same group of participants with autism was used across all three experiments, it was of particular interest to determine whether individual differences in patterns of performance across the three face processing tasks were present. Both parametric and nonparametic statistical analyses indicated no significant patterns of individual differences in performance, even when taking into account VMA and CA of participants autism.

At issue is what underlying mechanism might account for deficits in face processing abilities in children with autism. Several models have been posited to account for results such as those found in the present study. One possibility is that of a domain specific social deficit (Dawson et al. 2005; Klin et al., 2003; Schultz, 2005). An alternative possibility is that of a domain general cognitive/perceptual deficit, which affects all aspects of cognition, including social cognition (Klinger and Dawson, 2001; Strauss, 2004).

5.1 SOCIAL MOTIVATIONAL/AFFECTIVE EXPLANATIONS OF FACE PROCESSING IMPAIRMENTS IN AUTISM

Dawson and colleagues (2005) suggest a social motivational/affective explanation of face processing impairments. Face processing deficits, under this account, are thought to be caused by a fundamental deficit in social motivation. Limited social motivation causes reduced attention not only to faces but to other social stimuli such as hand gestures and voices. This lack of attention leads to decreased expertise in configural processing of faces, which in turn leads to differences in brain functioning in individuals with autism. The authors speculate that "social motivational impairments in autism are related to a difficulty in forming representations of the reward value of social stimuli", (Dawson et al. 2005, pg. 415). This may be due to abnormalities in neural systems important for the perception of social rewards (Decety, Chaminade, Grezes, & Meltzoff, 2002; Decety & Sommerville, 2003; Meltzoff & Brooks, 2001).

Dawson et al. (2005) further hypothesize that in typically developing children, representations regarding the reward value of social stimuli begin to motivate and direct attention during the second half of the first year of life. Because children with autism do not experience this social motivation, they spend significantly less time observing human faces. Consequentially, children with autism fail to become experts in face processing. Drawing from

Nelson's (2001) theory that experience drives cortical specialization for faces, this lack of experience may further result in a failure of specialization of regions of the brain that typically mediate face processing. Atypical functioning in cortical areas proposed to drive face perception has been identified, and results have been replicated across studies (e.g., Aylward et al., 2004: Curby et al., 2003; Hall, Szechtman, & Nahmias, 2003; Pierce et al., 2001; Schultz, et al, 2000b). It has not been shown, however, whether identified atypicalities in cortical regions are a cause, or a result of differential face processing abilities in children with autism. The authors also propose that this lack of neural specialization is further evidenced by slower information processing speed for faces. Slower processing speed for faces, as evidenced by EEG studies showing longer latency to peak in neural circuits proposed to be specialized for faces, have also been documented in the case of autism (McPartland, et al., 2004; Webb, et al., 2003).

However, because there is no reliable method of diagnosing autism in infancy, there is very little empirical support for this early lack of attention to social information. Only one case study of an infant who was later diagnosed with autism has been presented (Dawson et al., 2000). Early data from this study suggests that during the first six months of life the infant smiled responsively and exhibited generally good eye contact. It was not until closer to one year of age that eye contact was rated as poor. This would seem to suggest that very early attention to face was more typical, drawing into question the assertion that infants with autism do not find faces inherently interesting. This was only a case study, however, and more studies examining the social behavior of infants with autism need to be conducted when and if it is possible to identify this disorder earlier in development.

Another model suggesting that a primary social motivational/affective deficit accounts for poor face perception skills in children with autism has been proposed by Schultz (2005). This model suggests there is primary developmental failure in the amygdala, which causes a cascading influence on the development of cortical areas that mediate social perception in the visual domain. More specifically, it is proposed that typically developing infants are born with a perceptual bias for face-like stimuli. This bias, combined with associative and instrumental learning during infancy, as well as the influence of amygdala functioning, leads to enhanced salience of faces. As a result, there is more attention to and subsequent experience with faces, and therefore greater perceptual skill. Enhanced attention and the resulting increase in perceptual skills for face processing are thought to be influenced by a region of the ventral temporal lobe, known as the fusiform face area (FFA) of the fusiform gyrus (FG). Greater skills with faces ultimately leads to scaffolding of more general social skills development.

As Schultz (2005) explains, the amygdala reacts quickly to emotionally laden stimuli, signaling other brain areas to the salience of an event (LeDoux, 1996; Schultz et al., 2000a) and mediating formation of “emotional learning” (Anderson and Phelps, 2001; Anderson and Sobel, 2003; Gaffan et al., 1988; LeDoux, 1996). The amygdala provides critical emotional information to cortical areas, such as the FFA, for further processing. Deficits in face processing abilities, as caused by deficiencies in the amygdala-fusiform system could then lead to multiple difficulties in social interaction.

There is evidence to suggest that both amygdala and FFA abnormalities in functioning are present in individuals with autism. In postmortem examinations of the brains of individuals with autism (Bauman & Kemper, 1994; Kemper & Bauman, 1998), neurons in the amygdala were found to be small and densely packed because of the limited development of dendritic trees (Schultz, 2005). More recently, fMRI studies have found that the amygdala is hypoactivated in individuals with autism during face perception tasks (Baron-Cohen et al., 1999; Critchley et al., 2000; Pierce et al., 2001). Hypoactivation during face perception tasks has also been found across many autism fMRI and PET studies of the Fusiform Face Area (e.g., Aylward et al., 2004: Curby et al., 2003; Davidson et al., 2004; Hall et al. 2003; Pierce et al., 2001; Schultz, et al., 2000b). Piggot et al. (2004) were the first to use a sample of just children (N =14), and found similar results, hypoactivation of the FFA when facial stimuli were presented. Despite the impressive body of evidence supporting both amygdala and FFA abnormalities, Schultz (2005) himself points out a difficulty with interpreting such evidence. He purports that hypoactivation data in autism are not, by themselves, convincing evidence of a cause-effect relationship. Rather it would be just as easy to argue that autism is the cause of the hypoactivation of both the FFA and amygdala, not the result. Research continues to address this question.

In summary, both Dawson and colleagues (2004) and Schultz (2005), suggest a model of domain specific social impairment, which accounts for both social and non-social cognitive deficits seen in autism. Alternatively, it may be that a more general cognitive/perceptual deficit impacts not just cognitive processes, but also impacts the abilities needed to process social information. Indeed, the deficit may not be just social in nature but social cognitive.

5.2 BEYOND WEAK CENTRAL COHERENCE: EVIDENCE FOR A COGNITIVE EXPLANATION FOR FACE PROCESSING DEFICITS FOUND IN AUTISM

While domain specific social motivational/affective models can account for deficits found in social functioning in those with autism, the mechanisms by which these models account for general cognitive deficits is less clear. One model that accounts for more general cognitive/perceptual deficits found in individuals with autism is weak central coherence (Frith, 1989; Frith & Happe, 1994a; Happe, 1999; Shah & Frith, 1983, 1993). Recall that this model suggests individuals with autism process information at a local or featural level, primarily due to a deficit in constructing and processing global or configural aspects of stimuli. In addition, despite the fact that information is processed at a featural level, individuals with autism are expected to have difficulty abstracting this featural information from various exemplars to form a conceptual whole. Support for this model includes data indicating that individuals with autism show superior performance in processing featural versus configural stimuli (Happe, 1996; Joliffe & Baron-Cohen, 1997; Mottron, Belleville, & Menard, 1999b; Shah & Frith, 1983, 1993) and a deficit in the ability to abstract featural information to form prototypes (Klinger & Dawson, 2001; Plaisted, 2001).

A model that extends the perceptual/contextual deficits explained by weak central coherence theory into the realm of face perception is Valentine's face-space framework (1991, 1999). As previously explained, Valentine's model of face perception abilities in adults necessitates the ability to process faces beyond the featural level and to abstract and store information. In addition, expertise is acquired with experience. Results of the present study are consistent with deficits found as predicted by weak central coherence and its application to the face space framework.

However, results of the present study also raise an interesting question that cannot be answered by extending the understanding of weak central coherence theory to Valentine's face-space framework. Although the present study found significant differences in performance across all three face processing tasks, it did not indicate that children with autism were unable to perform face processing tasks at all. Rather, a relative weakness compared to controls was observed. For example, when identifying the gender of individuals judged to be average examples, children with autism were 87% accurate versus a 96% accuracy rate for controls (when hair cues were provided). When no hair cues were provided, children with autism were 79% accurate versus 92% for controls. If children with autism were not using configural strategies, as predicted by weak central coherence, to process facial information, it would be expected that their performance would be below chance on face perception tasks. Clearly, this was not the case; therefore an alternative explanation for these results must be sought. Another general cognitive/perceptual model, enhanced perceptual functioning, may provide explanatory power for the relatively poorer, although intact face processing abilities found in the present study.

5.3 ENHANCED PERCEPTUAL FUNCTIONING IN AUTISM

While weak central coherence (Frith, 1989; Frith & Happe, 1994; Happe, 1999; Shah & Frith, 1983, 1993) posits that superior featural processing is due to a deficit in configural processing, proponents of enhanced perceptual functioning (Mottron et al., in press, Mottron & Burack, 2001) attribute a featural bias in autism to a relative superiority of featural processing without accompanying deficits in configural processing. This hyper-functioning of featural, or low-level processing is thought to be mandatory, which interferes in situations where configural processing would be more advantageous. Therefore, configural processing, though intact, may be obscured by the hyper-functioning of low-level processing. In other words, the default setting of autistic perception is more locally oriented than that of typically developing individuals. Hence, an opposite pattern of processing emerges in autism compared with controls. In typical adults, top down or higher order processing takes precedence over low level perceptual processing, for example the Gestalt principles of perceptual organization.

The authors provide evidence to support their claims using various tasks administered across different labs. For example, concerning conflicting findings regarding visual illusion performance, such as in the case of the Muller-Lyer illusion in individuals with autism, Brownan et al. (2004) stated that individuals with autism are sensitive to that illusion only when asked 'which line *looks* longer,' but not when asked 'which line *is* longer.' This finding suggests that while autistic perception is oriented towards the local level, global information is available. Further evidence comes from studies using the Block Design (BD) task of the Wechsler scales, where individuals with autism have been shown to perform significantly better than typically developing individuals (Shah and Frith, 1993). In the BD, each trial involves processing at a local level (a single block) and a global level (the figure). When processing at the global level (completing the figure) conflicts with processing at the local level (segmentation of design into individual blocks), individuals with autism perform at a level superior to comparison groups. A similar effect was found for two other tasks that involved both local and global processing, reproduction of possible and impossible figures (Mottron, Belleville & Menard, 1999b) and the Embedded Figures Task (Joliffe & Baron-Cohen, 1997).

A more recent study by Behrmann et al. (2006) lends further support to the hypothesis of a local bias with intact global processing (which is predicted by the Enhanced Perceptual Functioning model). Navon (1977) stimuli were used for this experiment. Navon stimuli are large hierarchical letters made up of small letters. The identity of the local letters is either consistent or inconsistent with those at the global level. Subjects are asked to identify the letter either at the global or local level. In typically developing individuals the global letter is identified faster than the local letter. When the inconsistent condition is presented, however, a global-to-local interference is found, in which participants are more likely to identify the global letter than the local one, regardless of which one they were asked to identify. For typically developing individuals, Behrmann and colleagues replicated Navon's results, finding a slight advantage for global over local processing in the consistent case and greater slowing in the inconsistent case when local identification is required (interference from locally incongruous letters). Although participants with autism were slower overall, a different pattern of performance was observed for them. No differences in speed for global or local processing were found in the consistent trials. In the inconsistent trials, however, an advantage was found for local over global processing (the opposite finding of the control group). These finding are consistent with predictions made by the Enhanced Perceptual Functioning model; a bias towards local over global processing.

This local over global processing bias is further evidenced by a failure of individuals with autism to abstract information to form an average, or prototype (Gastgeb Strauss & Minshew, submitted for publication; Klinger & Dawson, 1995, 2001; Plaisted, 2000; Strauss, 2004), in a manner analogous to controls. According to Valentine's face-space model, individuals compare each exemplar, or face, with prior stored representations during recognition memory. The face-space framework is densely populated at the center of the axes, where average feature and face information is stored. Atypical exemplars, or faces with distinctive features, are stored in the periphery and therefore information about distinctive faces is more readily accessible. Hence, a distinctiveness effect occurs, wherein more distinctive faces are more easily remembered. Results of the current study, indicating that individuals with autism do not show a distinctiveness effect, are consistent with the prediction that would be made using Valentine's model.

Taken together, these studies support the claim that cognitive/perceptual differences, as predicted by weak central coherence and enhanced perceptual functioning are present in autism. The weak central coherence model and the enhanced perceptual functioning model both provide explanatory power within the context of Valentine's face space model, when attempting to understand face perception deficits found in autism. It may be that due to a local perceptual bias, children with autism do not become expert processors of configural face stimuli even though they *can* process configurally under some circumstances. This lack of expertise in face processing has been documented across many studies, but it is possible that this deficit extends beyond face processing to other types of stimuli as well. It could be that the complexity of face stimuli renders the task more difficult and so deficits are more apparent with faces. If the enhanced perceptual functioning model truly applies to cognitive abilities outside of the social realm, however, then a similar lack of expertise should be apparent in the processing of non-social stimuli as well. Currently, both neuroimaging studies and behavioral studies provide converging evidence suggesting that individuals with autism lack expertise in processing both social and nonsocial stimuli.

5.4 NEUROIMAGING STUDIES

Since the time that Kanwisher et al. (1997) first identified a region of the ventral temporal lobe known as the fusiform face area (FFA) numerous neuroimaging studies have examined the function of this area of the brain. The FFA, located within the lateral portion of the fusiform gyrus (FG), differentially activates during the processing of face stimuli (Haxby et al., 1994, 1999; Kanwisher et al., 1997, 2000; Puce et al., 1995). Kanwisher (2000) asserts that FFA activity is twice as strong when viewing faces as compared with non-face stimuli such as backs of heads, animals without heads, and objects. Evidence suggests that FFA engagement is automatic and mandatory when presented with faces or complex face-like stimuli (Winston et al., 2004). Although all previous FFA studies found activation only for face like stimuli, Gauthier and colleagues (1998) questioned the accuracy of conceptualizing the FFA as specific to face processing. Gauthier noted that faces are complex stimuli that vary only slightly from one another at the exemplar level. Since all typical adults are exposed to a myriad of faces throughout life, they have become experts at face processing.

At issue is whether the FFA of the FG is solely dedicated to face processing, or whether it actually represents an area of the cortex that activates when "experts" process subordinate level information. In an ingenious series of experiments, Gauthier and colleagues (2000) demonstrated that the FFA is also activated when participants who are experts with cars or birds view pictures from their area of expertise. Conversely, FFA activation does not occur when experts view stimuli outside of their area of expertise (e.g. a car expert examining bird stimuli). Similarly, she has shown a significant increase from baseline to post-test FFA activation (Gauthier et al., 1998) for participants who are trained to be experts at recognizing subordinate-level novel stimuli called "greebles" (unfamiliar 3D objects with controlled variations in spatially distributed features).Since individuals with autism are *not* expert face processors, it is not surprising that numerous fMRI studies have found FFA hypoactivation when face stimuli are examined (Aylward et al., 2004; Curby et al., 2003: Critchley et al., 2000; Davidson & Dalton, 2003, 2004; Hall et al, 2003; Hubl et al., 2003; Pierce et al., 2001; Piggot et al., 2004).

If a lack of expertise for faces stems from a general cognitive/perceptual deficit rather than a specific social deficit, then the lack of expertise, as evidenced by fMRI activation should extend beyond face (i.e., social) stimuli, to encompass non-social stimuli as well. Previous studies examining object perception abilities in individuals with autism have found object processing to be intact, compared with impaired face processing abilities. Upon more careful examination of the stimuli used in studies comparing face versus object processing, a methodological problem emerges. Object stimuli used in these studies differed at the basic level (cat versus dog) or at the subordinate level (office building vs. church) from one another. Objects varying at the exemplar level (one church from another church), were not used. In other words, differences between the object stimuli were distinctive enough that expert abilities were not necessary to distinguish them. At the same time, differences between facial stimuli used were much more subtle (i.e. at the exemplar level), requiring greater expertise to differentiate them. Thus, it is difficult to say whether individuals with autism were better objects than face processors, or whether task demands were simply different between these classes of stimuli.

5.5 BEHAVIORAL STUDIES

Several recent autism behavioral studies (Behrmann et al., 2006; Gastgeb et al., submitted for publication) have started to address this issue, with results suggesting a domain-general relative lack of expertise in processing perceptual stimuli. For example, Behrmann et al. (2006) found that under conditions where fine grained or exemplar-level discrimination of objects was required, fourteen individuals with autism were impaired relative to controls. In this task, the authors presented objects that were either similar or different at the basic, subordinate, or exemplar level, and participants were asked to designate the pictures as either the "same" or "different." Individuals with autism were significantly worse than controls at distinguishing exemplar-level differences, suggesting a lack of expertise in object categories.

Gastgeb et al. (submitted for publication) found that individuals with autism were impaired, relative to controls in processing and categorization of object stimuli. Results indicate that individuals with autism were less able to categorize category members if those members were atypical examples. The authors speculate that the categorization of atypical category members requires a type of processing more similar to that used when discriminating individual members of subordinate categories such as *desk* chairs versus *rocking* chairs. Since subordinate category members look very similar, the discrimination of one category member from another involves more complex processes that become available with developing expertise (Tanaka & Taylor, 1991; Gauthier & Tarr, 1997).

In summary, although the results of the present study indicate that significant face processing differences are present by the age of five to seven in children with autism, the results cannot provide support for either a domain general cognitive/perceptual processing impairment or a domain specific processing impairment. However, Behavioral studies from Berhmann et al., (2006) and Gastgeb et al. (submitted for publication) provide preliminary support for a general cognitive/perceptual impairment that may affect the development of processing expertise. Studies by Gauthier and colleagues (1998, 2000) provide neuroimaging evidence that the FFA area of the FG is activated during expert-level processing of complex stimuli, and numerous studies have shown hypoactivation in the FFA in individuals with autism.

Although the authors of these expert processing studies provide support for a domain general cognitive/perceptual explanation of face processing differences in autism, it is important to state that many more studies need to be conducted before conclusions can be drawn. This paper has speculated that a general cognitive deficit may be affecting face perception. A cognitive/perceptual deficit model, enhanced perceptual functioning, predicts general deficits that, if found to occur in Valentine's face-space framework, could account for the pattern of performance in face recognition tasks seen in children with autism. Although the direction of effects is entirely speculative at this point, it seems more difficult to imagine how a social-specific deficit could account for general cognitive deficits, such as those found in autism.

While there have been numerous studies of face processing abilities in older children with autism, this is the first study to examine recognition memory, gender identification, and identification of expression of emotion in a younger (five to seven) population. While the cause of these deficits is unknown, one possibility is that they represent general deficits in how individuals with autism process information. Unknown, is whether there is developmental improvement in face processes. Studies by Gastgeb et al. (submitted for publication), and Strauss, Newell, Giovannelli, & Minshew (in preparation) suggest that with both objects and faces, there are improvements in processing information as individuals with autism reach adolescence and adulthood. However, with both objects and faces, they do not develop the same level of expertise as do typically developing individuals. This suggests that perhaps they never acquire the ability to truly process stimuli configurally, and compare stimuli to abstracted representations. Finally, the present studies were conducted with individuals who were high functioning. Face and object processing deficits may be more severe in lower functioning individuals with autism. It is also unknown whether these deficits begin within the first year, as speculated by Dawson et al. (2005) and Schultz (2005). Perhaps future studies of this nature using infant siblings of children with autism will be able to address this issue.

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