THE RELATIONSHIP BETWEEN MOTOR PERFORMANCE AND EMOTION RECOGNITION ABILITIES IN CHILDREN WITH AUTISM SPECTRUM DISORDERS

by

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ABSTRACT

Autism Spectrum Disorder (ASD) affects 1 in every 88 people, causing deficits in social skills and communication, along with repetitive behaviors and narrow interests. Motor impairments are not considered a diagnostic criterion for ASD, but are widely reported. This study examined emotional bodily expression recognition accuracy relative to facial expression recognition and combined body/face expression recognition in children with ASD, as well as relationships between motor performance and recognition ability. Thirty children with ASD completed 3 computerized emotion recognition tasks, as well as a motor assessment. Repeated measures ANOVA comparing recognition across tasks revealed that bodily expressions were most accurately recognized. A comparison of bodily expression only and composite face-body tasks revealed that bodily expressions were more accurately recognized, but there were no significant differences between individual emotions. Subsequent correlational and regression analyses indicated that motor performance could significantly predict global emotional and sad bodily expression recognition, as well as recognition of happy face-bodies and complex facial expressions of emotion. Overall, results suggested that children with ASD show body superiority during emotion recognition compared to faces alone or composite stimuli. Furthermore, certain fine and gross motor skills are able to predict emotion recognition, especially from the body alone. While exploratory, findings can help guide future research, especially in areas for better social intervention in ASD, as well as possibly adding to early detection and diagnosis.

CHAPTER I

INTRODUCTION

Autism Spectrum Disorder (ASD) represents a set of behaviors present in one in every 88 children, affecting males at a rate five times higher than females (Center for Disease Control and Prevention; CDC, 2014). At this time, ASD is diagnosed based on a set of behavioral criteria, which are manifested by three years of age (CDC, 2014). These criteria include repetitive behaviors and narrow interests, as well as deficits in social behavior and delays in verbal and nonverbal communication, (APA, 2013). Skills critical for adaptive social behavior, such as perceiving others' emotional states via verbal and nonverbal cues, are not as developed in children with ASD. For example, children with ASD often exhibit socially awkward behavior, decreased positive affect, decreased joint attention and social interest, inability to properly initiate or carry conversations, reduced empathy and emotion recognition (e.g., Dawson et al., 2004; Mundy, Sigman, Ungerer, & Sherman, 1986; Travis & Sigman, 1998; Zwaigenbaum et al., 2005).

Despite the disorder's heterogeneous nature, social impairments are a prominent feature of ASD. In his original case studies on children with ASD, Kanner (1943) wrote, "We must, then, assume that these children have come into the world with innate inability to form the usual, biologically provided affective contact with people (p.250)." The ability to recognize others' emotions is a cornerstone of affective and social function. Salovey and Mayer (1989) argued that this ability to perceive emotions subserves emotional intelligence, and that emotions make social and personal communication more rewarding. Thus, impairments in emotional intelligence that are common in ASD, might diminish rewards associated with social and personal communication, reducing social interactions and leading to ostracism (Salovey & Mayer, 1990).

Since Ekman and Friesen's (1971) landmark study on emotional facial expressions, the face has become the chief source of stimuli for assessing emotion recognition (de Gelder, 2009). Typically developing (TD) populations accurately perceive facial expressions of emotion while ASD populations show the opposite trend (e.g., Ekman, 1992; Gunes, Piccardi & Pantic, 2008; Hobson, 1986a, 1986b; Hobson & Lee, 1997). Recently, bodily expressions have become an area of interest (for review see Gunes, Piccardi & Pantic, 2008). Outside laboratory settings, people extract information about others' emotional states from bodily expressions as well as facial expressions; however, there is a lack of research in this area, especially in children with ASD.

Bodily expressions of emotion require movement and motor skills, which are impaired in children with ASD (e.g. Lloyd, MacDonald & Lord, 2013; Ming, Brimacombe & Wagner, 2007; Zachar, Illenit & Itzchak, 2010). Recently, some researchers have suggested a relationship between emotion perception abilities and motor skills (Fogel 1992; Fogel et al., 1992; Grezes & de Gelder, 2009) such that deficits in one area may potentially affect the other. For example, research has shown that participants with Huntington's disease (HD) and schizophrenia, which are accompanied by motor deficits, show impairments in recognizing certain emotions expressed in others' body language (de Gelder, Van den Stock, de Diego Balaguar and Bachoud Levi, 2008; Van den Stock, de Jong, Hodiamont, & de Gelder, 2011). While children with ASD do show impairments in recognition of bodily expressions, as well as motor deficits, no studies have explicitly examined their relationship.

Currently, emotion recognition in ASD has been overwhelmingly studied using facial expressions, suggesting impairment in this domain. However, recent research has shown that an understanding of emotion recognition is limited without the addition of bodily expressions. For this reason, the current study focused on bodily expressions as well as facial expressions, which show similar impairments in ASD children. Nevertheless, there have been no explicit comparisons between stimulus dimensions. The current study sought to add to the overall literature on emotional bodily expression recognition by comparing the recognition accuracy from bodily expression with facial expressions only and combined faces and bodies. Additionally, research has shown that underlying mechanisms of emotion perception are also impaired in ASD, and that motor abilities may be related to this impairment. For this reason, the current study explored possible associations between motor performance and emotion recognition abilities.

CHAPTER II

LITERATURE REVIEW

Emotion recognition in ASD has been widely studied; however, the vast majority of the research has focused on faces. Furthermore, children with ASD often present diagnostic symptoms that are accompanied by motor performance deficits. Compounding research over the last two decades suggest motor impairments may be more than simply secondary, especially with regard to emotion recognition. Thus, these are the two main foci of the current research. The following literature review sheds more light on these issues with respect to ASD. Initial findings of emotion recognition impairments are discussed first, demonstrating that faces have been the focal point for emotion recognition abilities. Next, research supporting the inclusion of bodily expressions of emotion is reviewed in both TD and ASD subjects. This is followed by a review of motor impairments that often accompany core ASD behavior deficits, and finally newer theories are presented that integrate these findings to explain the possible relationships between motor performance and emotion recognition.

Emotional Expression Recognition Deficits in ASD

In a series of emotion expression-matching experiments with ASD, TD, and mentally retarded (MR) participants, Hobson (1986a, 1986b) demonstrated emotion recognition impairments in ASD. In the first experiment, participants observed or heard actors performing happy, unhappy, angry, or fearful bodily or vocal expressions, then chose the corresponding facial expression from an array. Participants also completed a similar control task, except the stimuli consisted of cars, dogs, trains, and birds (Hobson, 1986a). In experiment two, Hobson (1986b) substituted bodily gestures for emotional facial expressions but kept the same basic design, replacing the original control task. Participants now viewed recordings of actors performing a series of non-emotional but purposeful movements, and then asked to choose a related drawing that would accurately extend the events seen on film. Results from both experiments indicated significantly lower accuracy scores in the ASD group on emotion-related tasks but not the control tasks, suggesting recognition deficits in ASD children were specific to emotion.

Subsequent research supports the presence of emotion recognition deficits in ASD across tasks, ages, and control groups. Tantam, Monaghan, Nicholson, and Stirling (1989) found that children with ASD performed significantly worse than TD controls when both identifying emotions from facial expressions and finding the odd emotional facial expression presented alongside three identical emotional facial expressions. Compared to MR controls, children with ASD showed poorer performance when matching corresponding facial and vocal emotional expressions but not non-emotional object and sounds (Hobson, Ouston, & Lee, 1988). During sorting-by-preference tasks, children with ASD overwhelmingly sorted pictures based on the models' type of hat rather than their facial expressions of emotion (Weeks & Hobson, 1987). Recently, Begeer, Rieffe, Terwogt, and Stockmann (2006) extended Weeks and Hobson's (1987) findings, using different emotional and non-emotional stimuli, such as angry expressions, mustaches, and glasses, and found similar group differences. Celani, Battacchi, and Arcidiacono (1999) compared emotion recognition abilities amongst ASD and TD children and adolescents, and children with Down's Syndrome (DS). ASD group performance was lowest when matching pictures of happy, sad, neutral, or wry facial expressions. In a follow-up task, the ASD group showed less proficiency in sorting faces based on happy or neutral expressions, but not when sorting pictures of pleasant and unpleasant scenes without faces (Celani. Battacchi, & Arcidiacono, 1999).

Adult studies have found similar deficits in decoding expressions of emotion. Macdonald and colleagues (1989) found that ASD participants were worse at both recognizing vocal and facial expressions of sadness, anger, fear, and happiness, as well as expressing vocal and facial expressions of the same emotions. Bolte and Poustka (2003) found that adolescents and young adults with ASD performed significantly worse on a forced-choice labeling task of happy, sad, fearful, disgusted, angry, and surprised facial expressions compared to both TD and schizophrenic groups. Similarly, Philip and colleagues (2010) found that adults with ASD were also impaired when either labeling or matching sad, happy, fearful, angry, and disgusted facial expressions compared to TD adults. Results indicating impaired emotional expression recognition in children (e.g., Tantam et al., 1989) and adults with ASD (Philip et al., 2010) when compared to both TD and clinical control groups (e.g., Celani. Battacchi, & Arcidiacono, 1999; Weeks & Hobson, 1987), suggest this deficit is a global feature of ASD that has a deviant developmental trajectory of emotional development which is not merely delayed.

Nevertheless, some studies of expression recognition do not find deficits. For instance, Castelli (2005) created a series of continua, each bookended by two photographs of prototypical emotional facial expressions at 100% intensity and nine intermediary morphed expressions. Prototypical expressions included: anger, fear, disgust, happiness, sadness, and surprise, which were then combined to express emotions at 90%, 70% and 50% intensities. Castelli (2005) first instructed children with high-functioning autism (HFA) or Asperger syndrome (AS) and TD controls to match emotions at lower levels of intensity with its prototypical expression followed by two identification tasks. In the first, children tried to identify emotions seen in the prototypical stimuli, while the second task used the 90% and 70% morphed stimuli. No significant differences across groups were noted (Castelli, 2005). However, it is possible that performance on this task can be affected by other factors besides expression recognition. For example, the use of strategies that focus on the displacement of certain features (e.g., the mouth corners curling up during a smile) may have precluded the need to extract global information about facial expressions of emotion.

Conversely, other studies have found group differences in emotion recognition ability. Teunisse and de Gelder (2001) compared emotion perception from facial expressions in adolescents with HFA and TD controls through two-alternative forced-choice emotional expression matching and identification tasks. Similar to Castelli (2005), stimuli were images taken from three continua of morphed prototypical facial expressions of emotion: angry-sad, happy-sad, and angry-afraid. However, Teunisse and de Gelder (2001) created continua, consisting of nine intermediary facial expressions. This allowed for a larger sample of emotion intensities and more ambiguous expressions. In two of three tasks, Castelli (2005) used 70% and 90% intensities, which probably shared many unambiguous characteristics to their prototypical origin. Teunisse and de Gelder (2001) showed similar group performance during emotion identification but significantly worse HFA group performance during the emotional-expression matching. The authors suggested that the ASD group perceived emotional faces differently than the control group, relying on different emotion decoding mechanisms (Teunisse & de Gelder, 2001).

Earlier research has explored this phenomenon, pointing to increased use of featural or piecemeal processing rather than holistic, configural processing of faces in ASD. For instance, Tantam et al. (1989) found that emotion recognition was unaffected by inverting facial stimuli in the ASD group unlike controls. Early sorting-by-preference studies, reviewed above, depicted atypical sorting preferences, focusing on non-emotional characteristics of emotional faces (e.g., Begeer et al., 2006; Celani, Battacchii, & Arcidiacono; Weeks & Hobson, 1987). Baron-Cohen, Wheelwright, and Jolliffe (1997) found that HFA and AS participants performed as well as TD adults when viewing full, uncovered facial expressions of simple emotions (i.e., happy, sad, fear, sadness, disgust, and surprise) but not complex emotions (i.e., guilt, arrogance, thoughtfulness, flirty). However, when viewing only specific areas such as the eyes alone, performance in both emotion categories dropped dramatically below that of TD controls, suggesting HFA and AS participants decode expressions in a piecemeal manner based on the displacement of specific feature like the mouth or eyebrows rather than the configural properties of the features as a whole (Baron-Cohen, Wheelwright, & Jolliffe, 1997).

Thus, people with ASD may associate up-turned mouth corners with happiness, rather than the combination of mouth, cheek, and eye movements seen as a whole. Likewise, participants in Teunisse and de Gelder (2001) and Castelli (2005) may have successfully identified emotions based on specific features; however, the increased ambiguity of these features in Teunisse and de Gelder (2001) may have affected matching accuracy more than in Castelli (2005). Furthermore, this suggests a possible impairment in the underlying mechanism for emotion perception and processing, and, in turn, a lack of understanding of the emotional meaning conveyed from expressions.

Indeed, eye-tracking studies have shown that children with ASD scan and process faces differently than TD children. Pelphrey et al. (2002) found that participants with ASD focused less on core emotional areas such as the eyes and central part of the face than controls during general and emotional facial expression processing. Similarly, neuroscientific research has reported a number of differences between AD and TD during emotional facial expressions processing. Dawson, Webb, and McPartland (2005) reviewed event-related potential (ERP) findings comparing ASD and TD groups during face processing. Specifically, the N170 component is sensitive to faces and eyes, showing increased amplitude and shorter latency for faces than object in TD individuals (e.g., Joyce & Rossion, 2005); however, these differences were not seen in ASD groups, rather N170s from the ASD group had shorter latencies and larger amplitudes to objects (for review see Dawson, Webb, & McPartland, 2005). Additionally, Schultz and colleagues (2000) compared regional brain activations in ASD and TD control groups during face and object processing with functional magnetic resonance imaging (fMRI). Results indicated that TD participants activated the fusiform gyrus during facial processing more than during objects, while activating the inferior temporal gyrus during objects more than faces. The opposite pattern was seen in ASD participants (Schultz et al., 2000). Similar activation differences have been found in more recent fMRI studies along with hypoactivation in the amygdala and superior temporal sulcus (STS) during face processing in ASD groups compared to TD controls (Pelphrey, Morris, McCarthy, & LaBar, 2007; for review see Harms, Martin, & Wallace, 2010).

In all, the existence of emotion recognition impairment in ASD has been well documented. Contrasting findings are largely behavioral, and recent meta-analytic comparisons have definitively shown that a deficit does exist (Uljarevic & Hamilton, 2013). Regardless, eye-tracking findings have shown that children with ASD perceive facial expressions differently, and neuroscientific findings have demonstrated that underlying mechanisms process emotional information abnormally compared to TD controls (e.g., Pelphrey et al., 2002; Pelphrey et al., 2007). However, the literature in this field has been dominated by the use of facial expression stimuli. Recent research in TD populations, discussed in the next section, has shown similar behavioral performance and overlapping neural mechanisms during recognition of facial and bodily expressions of emotion (e.g., de Gelder, 2009). Unsurprisingly, initial findings have found similar deficits in emotion recognition from bodily expressions as in facial expressions (e.g., Critchley et al., 2000; Philip et al., 2010), suggesting that our understanding of ASD-specific emotion recognition impairments is incomplete without the inclusion of bodily expressions, which is the focus of the current study.

For instance, eye-tracking findings have shown atypical scanning and fixation patterns in ASD groups compared to controls (e.g., Pelphrey et al., 2002), while more recent data has shown that groups tend to look more at bodies than the face (e.g., Fletcher-Watson, Leekam, Benson, Frank, & Findlay, 2009; Klin, Jones, Schultz, Volkman, & Cohen, 2002; Riby & Hancock, 2009). Thus, there may be a body preference during emotion recognition in ASD. However, there has been paucity in explicit comparisons between the two stimulus dimensions. The current study directly compared emotion recognition from bodily and facial expressions. Specifically, current participants completed three computerized emotion recognition tasks, consisting of bodily expressions, facial expressions, or a combination of the two.

The discovery of the mirror neuron system (MNS), as a mechanism for matching observed actions onto the observer's own corresponding action execution networks, has led to a theory for recognizing and understanding those observed actions (e.g., Hadjikhani et al., 2006). This could explain impairments in emotion recognition, especially as children with ASD exhibit widespread motor performance delays (e.g. Lloyd, MacDonald & Lord, 2013). The current study explored this possibility by comparing emotion recognition performance with motor performance measured by the motor assessment battery for children second edition (MABC-2; Henderson et al., 2007).

Emotion Recognition from Bodily Expressions

Bodily expressions are also viable and accurate sources for emotion perception, utilized everyday outside the laboratory (for a review, see Gunes, Piccardi & Pantic, 2008). Furthermore, recent behavioral and neuroscientific findings suggest that the reliance on facial expressions, around 95% of the literature (de Gelder, 2009), has culminated in an incomplete understanding of human emotion recognition. Recent bodily expression research has questioned the dominance of the face as the primary source of nonverbal emotional information. Sogon and Masutani (1989) demonstrated possible universal recognition of bodily expressions of emotion by testing emotion recognition in Japanese and American participants, and found that participants accurately recognized emotions from' body expressions, especially sadness, fear and anger (Sogon & Masutani, 1989). Almost a decade later, Wallbott (1998) demonstrated that specific body movements alone were sufficient to communicate emotional states. Around the same time, Boone and Cunningham (1998) showed video clips of dancers performing happy, sad, angry, and fearful movement to children at four, five, and eight years of age as well adults. They found that by four years children could perceive sadness and reaching adult-like levels across emotions by eight years (Boone & Cunningham, 1998). More recently, it has been shown that recognition of bodily expressions of emotion is possible regardless of stimulus type (static vs. dynamic). Using forced-choice recognition tasks, Atkinson, Dittrich, Gemmell, and Young (2004) presented full- and point-light dynamic and static bodily expressions of anger, disgust, fear, happiness, and sadness to young, TD adults. Point-light displays are created by attaching lights to certain points on an actor's body, whose movements are then filmed in a dark room. These displays appear as easily decoded movements by points of light on screen, while full-light displays show an actor's full body minus the face. Atkinson et al.'s (2004) results indicated that emotions could be accurately perceived from body expressions across stimulus type.

Recent research suggests that bodily postures are not only viable markers of emotional state, but possibly necessary for accurate emotion perception. For instance, Meeren, van Heijnsbergen, and de Gelder (2005) presented young adults with pictures of either congruent or incongruent combinations of fearful and happy bodily and facial expressions, instructing participants to categorize the facial expression of emotion in each trial. Interestingly, participants also completed recognition control tasks for both the face and body alone, showing no significant differences between stimulus dimensions but an overall trend for increased accuracy from the body (Meeren, van Heijnsbergen, & de Gelder, 2005). The congruent-incongruent task indicated increased accuracy during congruent trials and a body over face preference when perceiving emotions from incongruent pairings. Van den Stock, Righart, and de Gelder (2007) replicated these findings with congruent and incongruent combinations of happy and fearful expressions.

Comparisons of emotion recognition between unidimensional (i.e., facial expression alone) and multidimensional (i.e., facial and bodily expressions together) designs give further support to the importance of bodily expressions in emotion recognition research. Gunes and Piccardi (2007) found increased emotion recognition accuracy from combined facial and bodily emotional expression stimuli compared to bodily or facial expression-only stimuli. This has led some researchers to suggest, during emotion recognition, the face and body are perceived holistically as a single unit (Avezier, Trope, & Todorov, 2012). These findings attest to the need for a better understanding of how humans extract emotion from nonverbal cues like body postures, as well as how this information is combined with facial expression to make inferences about another's emotional state.

Behavioral evidence of the integration of facial and bodily expressions is mirrored by neuroscientific findings that suggest that there is both functional and neuroanatomical overlap during emotion recognition from both these dimensions. fMRI studies, examining activation during fear perception from static (de Gelder et al., 2004) and dynamic (Grezes, Pichon, & de Gelder, 2007) bodily expressions, indicated increased activity in the amygdala, the insula and motor areas, the orbitofrontal cortex (OFC) and posterior cingulate cortex (PCC), and the temporal pole, echoing areas found in emotion facial expression recognition (e.g., Haxby, Hoffman, & Gobbini, 2000, 2002). Respectively, these areas were previously associated with perceiving and attenuating to socially salient emotional expressions and information, making social judgments, and attributing meaning and intentions from faces, while the temporal pole connected sensory and limbic areas (Adolphs, Tranel, & Damasio, 1998; for further review see Adolphs, 2001; Moran, Mufson, & Mesulam, 1987; Shallice, 2001; Struss & Levine, 2002). In a subsequent fMRI study, Van de Riet, Grezes, and de Gelder (2009) explicitly compared activations during perception of facial and bodily expressions of happiness and fear. They found that parts of the STS, cerebellum, sensorimotor cortex, inferior frontal gyrus (IFG), insula, and fusiform gyrus were activated across emotions and stimulus dimensions, while fear specifically increased activation in the amygdala (Van de Riet, Grezes, & de Gelder, 2009). Therefore, processing emotional information from the body and the face typically involves similar neural substrates, giving rise to the possibility that these abilities are inter-related.

Several other lines of evidence converge with this proposition. For example, electromyogram (EMG) and event-related potential (ERP) findings during multimodal emotional expression perception also suggest a single, shared emotion perception network. Magnee, Stekelenburg, Kemner, and de Gelder (2007) found similar facial electromyogram (EMG) results during happiness and fear perception from facial, vocal, and bodily expression perception. Additionally, Stekelenburg and de Gelder (2004) showed similar N170 and vertex positive potential component latencies to fearful facial and bodily expressions in areas typically associated with facial information processing. Specifically, they examined the N170 component over the occipitotemporal region, typically associated with face selectivity (e.g., Linkenkaer-Hansen et al., 1998), processing emotional facial expressions (e.g., Batty & Taylor, 2003), and sensitivity to congruent but not incongruent facial and bodily expression combination (e.g., Meeren, van Heijnsbergen and de Gelder, 2005). The VPP, possibly representing the positive end of the N170 dipole, has been associated with face detection in STS, fusiform gyrus, and occipital cortex areas (e.g., Joyce & Rossion, 2005).

The research reviewed in this section suggests that a complete understanding of emotional expression perception should include an understanding of how we perceive bodily expressions of emotion. Behavioral findings demonstrate that bodily expressions convey emotions as well as facial expressions and possibly better for certain emotions (e.g., Meeren, van Heijnsbergen, & de Gelder, 2005). Furthermore, neuroimaging results indicate a possible shared neuroanatomical substrate during both facial and bodily emotional expression perception (e.g., Magnee et al., 2007; Van de Riet et al., 2009). Thus, children with ASD would be expected to show similarly impaired perception of bodily expressions of emotion as they do for emotional facial expressions.

Emotion Recognition Deficits from Bodily Expressions in ASD

As mentioned, there is a paucity of research examining deficits during perception of bodily expressions of emotion in ASD compared to facial expression; however, behavioral and neuroscientific findings suggest impairments. For instance, Moore, Hobson, and Lee (1997) found that children with ASD were significantly less accurate than TD and MR controls when identifying surprised, sad, fearful, angry, and happy bodily expressions from dynamic point-light displays. However, groups did not differ during observation of non-emotional, instrumental displays such as a person running or lifting an object, suggesting group differences were specific to perception of emotion rather than human movement (Moore, Hobson, & Lee, 1997). More recently, Hubert and colleagues (2006) replicated these findings in adolescents and adults with ASD compared to TD controls. Specifically, their results indicated no group differences in perceiving non-emotional movement, but significant impairments in performance in the ASD group performance in recognizing sad, fearful, angry, and happy bodily expressions (Hubert et al., 2006). These results support the notion that ASD is associated with impairments in perceiving emotion from body expressions, as well as facial expressions.

Subsequent research converges with these findings of impaired emotional bodily expression perception in ASD across experimental stimuli and tasks. Atkinson (2009) presented point- and full-light recordings of angry, happy, sad, fearful, and disgusted bodily expressions to TD and ASD adults in a five-alternative forced-choice emotion identification paradigm, finding that the ASD group was less accurate across all emotions compared to TD controls; however, significant differences were not found for sadness or fear identification. In a two-alternative, forced-choice matching design, Hadjikhani and colleagues (2009) instructed TD and ASD participants to match pictures based on either bodily expressions of sadness, anger, fear, or on non-emotional actions. Results indicated significantly lower emotion perception accuracy but significantly higher non-emotion perception scores in ASD participants compared to TD controls (Hadjikhani et al., 2009), supporting earlier claims of global deficits in emotional expression perception abilities (e.g., Hobson 1986a, 1986b; Macdonald et al., 1989; Moore, Hobson, & Lee, 1997).

Guided by these findings indicating similar patterns of impaired emotional expression recognition in ASD across stimulus dimensions, Philip and colleagues (2010) compared adult TD and ASD participants on tests of emotion recognition across vocal, facial, and bodily expressions. In a series of five-alternative forced-choice tasks, participants attempted to identify expressions of happiness, sadness, anger, disgust, and fear. In addition, participants made age, trustworthiness, intelligence, attractiveness, approachability, and distinctiveness judgments about facial stimuli. Compared to controls, the ASD group was significantly less accurate in recognizing emotions across expression dimensions and atypical when making social judgments of approachability, attractiveness, intelligence, and distinctiveness (Philip et al., 2010). Furthermore, Philip et al. (2010) found that performance was significantly correlated across the three emotion recognition tasks, and that the overall emotion recognition score (the average from all three tasks) was significantly correlated with overall social judgment performance.

Philip et al.'s (2010) findings offer more definitive evidence of global emotional expression impairment in ASD. However, there is a dearth of within-group research, comparing relative emotional expression perception ability across stimulus dimensions (i.e., face and body). Furthermore, the interrelationship between emotion recognition from the face and body demonstrated in the TD literature has not been systematically examined in ASD participants. To this end, the current study compared emotion perception performance across facial, bodily, and combined expressions in children with ASD. These abilities are hypothesized to be highly correlated because bodily expressions of emotion have been associated with impairments in social judgments (Phillips et al., 2010), possibly due to abnormal underlying emotion-processing mechanisms, (e.g., Adolphs, Sears, & Piven, 2001). In light of neuroimaging evidence of overlapping neural substrates in TD brains for processing emotion from both faces and bodies (e.g., Stekelenburg & de Gelder, 2004), and recent findings that TD participants could make accurate social judgments based on certain bodily expressions of emotion (e.g., Buisine et al., 2014), it can be assumed that these abilities are also interrelated in ASD.

Neuroimaging research supports this notion of multidimensional emotion processing impairment in ASD. As already reviewed above, people with ASD have shown decreased activation in brain areas during fMRI when processing facial expressions of emotion compared to TD controls such as the amygdala, fusiform gyrus, STS, and inferior temporal gyrus (e.g., Pelphrey, Morris, McCarthy, & Labar, 2007; for further review see Harms, Martin, & Wallace). Additionally, ERP results showed a lack of differentiation between object and faces normally seen in TD controls (for a review see Dawson, Webb, & McPartland, 2005). Accordingly, fMRI findings have indicated areas of the prefrontal cortex (PFC), amygdala, STS, and fusiform gyrus were hypoactivated during perception of dynamic point-light displays of non-emotional bodily motion relative to controls (Kaiser et al., 2007). Later fMRI results showed amygdala and insula hypoactivation (Hadjikhani et al., 2009), as well as IFG and PMC hypoactivation (Grezes, Wicker, Berthoz, & de Gelder, 2009) during perception of fearful bodily expressions in ASD groups compared to TD controls. Once again, these findings illustrate the similarities between facial and bodily expression perception and the need for increased multidimensional research. Furthermore, previous claims of impaired emotional expression processing mechanisms, subserving behavioral perception deficits, appear valid, warranting additional examination to help explain these perception deficits.

In the current study, recent embodiment theories served as the theoretical basis for explaining ASD-related impairments in emotional expression perception and overall socioemotional processing (e.g., Grezes & de Gelder, 2009). Specifically, an observer embodies another’s actions in his or her own action networks, allowing the observer to feel and understand those actions. This is subserved by the MNS, through an action observation-matching mechanism (e.g., Buccino et al., 2001). Thus, without a properly functioning MNS or motor network, it is predicted that one may not accurately recognize or feel observed emotional expressions (e.g., Enticott et al., 2012). To explore this, participants were assessed for the presence of motor performance delays and given corresponding motor ratings, which were analyzed in conjunction with performances from emotion perception tasks for relationships

Motor Performance Impairments in ASD

On the surface, motor skills seem unrelated to emotion perception abilities; however, recent research has proposed a link between the two, suggesting motor skills are vital to emotion perception (e.g. Grezes & de Gelder, 2009; Piek & Dyck, 2005). While not a core diagnostic criterion for ASD, motor performance deficits are widely observed (e.g. Lloyd, MacDonald & Lord, 2013; Ming, Brimacombe & Wagner, 2007; Zachor, Illenit & Itzchak, 2010), to the extent that some have argued for their inclusion in ASD diagnosis to differentiate levels of severity (Jansiewicz et al., 2006; Rinehart et al., 2006) or serve as an early warning marker (Liu, 2012). Overwhelmingly, research has indicated high levels of impairments among children with ASD. In a review, Matson, Matson, and Beighley (2011) found a greater rate of motor deficits in ASD compared to TD children, including decreased muscle tone (hypotonia; National Institute of Neurological Disorders and Stroke; NINDS, 2014), inability to carry out previously learned movements or skills (apraxia; NINDS, 2014), and gross motor skills deficits.

Children with ASD often exhibit deficits relative to children diagnosed with motor delay disorders. Provost, Lopez, and Heimerl (2007) compared fine and gross motor skills between children with ASD, children diagnosed with developmental delay and motor impairments, and children at-risk for delay without motor impairments. The authors found 100% of their participants with ASD exhibited motor delays with 84% showing significant delays in at least one battery of tests, performing comparably to children formally diagnosed with motor delay (Provost, Lopez, & Heimerl, 2006). Green et al. (2009) tested children with varying severities of ASD on the Movement Assessment Battery For Children (MABC; Henderson & Sugden, 1992), which tests fine and gross motor abilities in 4-12 year olds across eight tasks, covering areas of manual dexterity, ball skills, and balance. Green et al. (2009) found that 79% of children tested were delayed, while another 10% showed borderline delays.

Similarly, Miyahara et al. (1997) and Green et al. (2002) examined motor deficits in children with AS, using the MABC, and found AS participants also met criteria for diagnosis of Specific Developmental Disorder of Motor Functions (SDD-MF). Miyahara et al. (1997) reported motor deficits in 85% of AS participants, a rate 42 times higher than TD children at the time their research was published. Green et al. (2002) directly compared AS participants with a SDD-MF control group on the MABC as well as the Gesture Test (Cermak, Coster, & Drake, 1980), which requires participants to perform representational actions such as brushing teeth without the specific tools and also imitate non-meaningful actions performed by an experimenter. Compared to the SDD-MF group on both tests, the AS group performed showed impairments in performing and imitating meaningful actions (Green et al., 2002). Later, Hilton et al. (2007) correlated MABC scores with symptom severity measures from the Social Responsiveness Scale (SRS) in participants with AS. Their findings indicated a significant positive correlation between symptom severity and motor delay (Hilton et al., 2007). Together, these studies' findings point to motor skill deficits as a common feature of ASD.

Most recently, Liu and Breslin (2013a, 2013b) utilized the MABC-2 (Henderson et al., 2007). Liu and Breslin (2013a) first examined the effects of adding a picture schedule for visual support and explanation for the MABC-2 tasks on motor scores. Using traditional testing protocol for the MABC-2 (i.e., experimenters explain individual tasks then perform them if necessary), the authors found 96% of ASD participants were at risk for delays or delayed. Adding the picture schedule reduced this number to 76% of participants, suggesting some motor delays can be attributed to how children with ASD process testing instructions (Liu & Breslin, 2013a). However, 76% remains too large a number to ignore. Liu and Breslin (2013b) then compared children with ASD and TD controls, and found 77% of children with ASD were delayed while 3% were borderline delayed. Liu, Hamilton, Davis and El Garhy (2014) utilized the Test of Gross Motor Development-Second Edition (TGMD-2; Ulrich, 2000) to test ASD motor delays. The TGMD-2 tests gross motor skills in children ages 3-10 years, using 12 tasks spread across locomotor and object control skill areas. Each area produces raw subscores, which can be added together and standardized for comparison against age norms, providing evidence of motor delay and severity (i.e. very superior, superior, above average, average, below average, poor and very poor) of delay if any. The authors reported 67% of children with ASD had poor or very poor locomotor subtest scores while 60% had poor or very poor object control subtest scores. Overall gross motor scores showed that 91% of children with ASD met the criteria for delay while 96% of TD controls had average or above average abilities. Results from these studies demonstrate severe motor delays in ASD across assessment tools and testing conditions.

New areas of research have shown possible connections between motor deficits and emotion perception impairments in ASD. Emotional expressions consist of numerous motor actions, so this relationship makes intuitive sense. Grezes and de Gelder (2009) proposed that the accuracy with which a person can perceive another's actions, including nonverbal emotional expressions, depends on the observer's own abilities to perform these actions. Grezes and de Gelder's (2009) proposition is important considering the magnitude of possible body postures available to communicate emotions. For instance, Coulson (2004) was able to generate 176 computer images of different emotional body postures associated with anger, disgust, fear, happiness, sadness, and surprise, providing numerous opportunities to incorrectly perceive body gestures if one's own motor abilities are impaired. Indeed, Cummins, Piek, and Dyck (2005) found that children with motor difficulties and coordination issues had reduced scores on facial emotion recognition tests. While Cummins, Piek, and Dyck's (2005) study did not focus on ASD groups, the findings warrant further investigation in children with ASD, who also show fine and gross motor skill impairments (e.g. Liu, Hamilton, Davis & ElGahy, 2014; Provost, Lopez & Heimerl, 2006). New areas of research into the mirror neuron system (MNS) may provide a link between emotion perception and motor skills.

Mirror Neuron System and Emotion

Originally found in the PMC of macaque monkeys, researchers discovered the MNS via neurons that fired during action execution as well as during observation of that same action (di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992). Fadiga, Fogassi, Pavesi, & Rizzolatti (1995) replicated these findings in TD, human adults by showing similar motor-evoked potentials (MEP) amplitudes during action execution by participants and when participants observed actions. Specifically, the authors recorded increases in transcranial magnetic stimulation (TMS)-induced MEPs during action observation trials and compared the results to MEPs during action execution, TMS-induced non-action observation, and sensory perception trials. They found that action observation MEPs originated from the same muscles and were statistically similar to MEPs recorded from action execution trials (Fadiga, Fogassi, Pavesi, & Rizzolatti, 1995).

Mu rhythm suppression has been shown to be another indicator of MNS activation. Mu rhythm is recorded over the sensorimotor cortex and typically oscillates at frequencies between 8-13 Hz and 15-25 Hz during moments of rest, but is suppressed during action execution (Pineda, 2005). Lepage and Theoret (2006) examined the suppression of mu rhythm during electroencephalogram (EEG) recording. Children either observed an experimenter waving an open hand or gripping an object, similarly gripped the same object, or neither observed nor executed actions. Lepage and Theoret (2006) indicated mu suppression during both action observation and execution conditions, demonstrating the presence of a MNS in TD children.

Subsequent research with nonhuman primates has demonstrated enhanced MNS activation contingent upon the execution or observation of meaningful, goal-oriented actions (Rizzolatti, Fadiga, Gallese, & Fogassi, 1996). These findings, in concert with those of Fadiga et al. (1995), led Rizzolatti and colleagues (1996) to posit an internal, automatic mechanism for action recognitions, such as the execution of emotional expressions, that maps observed actions onto one's own corresponding action execution networks. More recently, fMRI research explicitly showed this neural mapping of observed actions onto one's own corresponding motor areas. Buccino et al., (2001) presented recordings of actors performing mouth, hand, and foot movements alone or directed at an object and found that observation of each body part was associated with somatotopic activation in the premotor cortex, extending to the parietal lobe during object inclusion trials (Buccino et al., 2001). Extending these findings, Iacoboni et al. (2005) found MNS activity associated with understanding the intention of observed actions as well as their recognition. Importantly, results from both studies indicated a distinct fronto-parietal connection at the core of the MNS as well as the STS and occipital regions involved in visual detection (Buccino et al., 2001; Iacoboni et al., 2005).

Unsurprisingly, many of these visual and fronto-parietal areas of activation overlap with studies on emotional expression perception due to their overlap with motor components (e.g., Haxby, Hoffman, & Gobbini, 2000, 20002; Van de riet, Grezes, & de Gelder, 2009. Furthermore, fMRI results indicated amygdala and insula activation during observation and imitation of disgusted facial expressions, suggesting functional connections between the emotion processing areas and the MNS, possibly mediated by the insula (Carr et al., 2003; for further review see Bastiaanson, Thioux, & Keysers, 2009; Gallese, Keysers, & Rizzolatti, 2004). In other words, emotional expressions in actors are perceived, in part, because they elicit activations during perception that are similar to those elicited during the actual performance of these expressions, a process mediated by the MNS. Subsequent research has supported this association between MNS activity and emotional expression processing. After measuring TMS-induced MEP baseline, Enticott and colleagues (2008) recorded amplitude changes in TD participants while observing clips of meaningful and meaningless action or no action to gauge MNS activation. Participants also completed a two-alternative forced-choice emotion discrimination task with happy, sad, surprised, angry, and neutral facial expressions as well as two forced-choice two-alternative identification tasks of dynamic or static images of surprised or fearful facial expressions. Emotion recognition was correlated with MEP results, showing significant positive correlations between MNS activity and emotion discrimination and identification of static facial expressions (Enticott et al., 2008).

It is evident that perceiving other's actions involves neural activation of the same motor areas that may extend to emotional expression recognition. Recent facial electromyographic (EMG) results support this by showing that TD adults often unconsciously mimic observed emotional facial expressions. In other words, neural activation extends to and recruits the corresponding muscle groups as well (Dimberg, Thunberg & Elmehed, 2000). Accordingly, Oberman, Winkielman, and Ramachandran (2007) blocked participants' ability to mimic facial expression during a two-alternative forced-choice identification task of happy, sad, fearful, and disgusted facial expressions by forcing participants to chew or bite, and found that blocking facial mimicry reduced the recognition of happy and disgusted facial expressions (Oberman, Winkielman, & Ramachandran, 2007). The authors suggested that they may have been unable to completely block mimicry of fear and sadness, thus explaining why recognition of these emotions was unaffected. Guided by this finding, Neal and Chartrand (2011) paralyzed facial muscles, via botox, or injected their faces with a tightening gel to enhance proprioception during emotional facial expression recognition. They found that the botox group performed worse than controls while the enhanced group performed better. This suggests that the ability to perform observed emotional expressions underlies the ability to accurately perceive them in others.

Considering the widespread deficits in emotional expression perception and motor performance in ASD research, impaired MNS functioning is a plausible explanation for deficits in social perception. This possibility has been systematically examined by a number of studies. For example, Hadjikhani and colleagues (2006) measured the cortical thickness in MNS areas of ASD participants and widespread found thinning along the fronto-parietal MNS network. Furthermore, increased levels of thinning were significantly correlated with decreased social scores on the Autism Diagnostic Interview-Revised (ADI-R; Lord, Rutter, & Le Couter, 1994). In a more recent TMS-induced measure of MEP changes, Enticott and colleagues (2012) found lower MNS activation in ASD participants when viewing clips of rest and action compared to TD controls. Moreover, measures of ASD severity were predictive of MNS responses, social impairment in particular (Enticott et al., 2012).

Recent fMRI findings have added structural clarity to potential MNS dysfunction among children with ASD. Dapretto et al. (2006) instructed children with ASD and TD controls to either observe or imitate emotional facial expressions. Both groups showed activation in the motor cortices, limbic structures such as the amygdala and insula as well as the cerebellum, and performed well during action imitation. However, ASD group results showed significantly less activity in the amygdala and insula and no activation in the pars opercularis of the IFG. Dapretto et al. (2006) correlated MNS activity in the pars opercularis and social subscores on autism diagnostic tests, finding a positive relationship between decreased IFG activity and social impairments. Dapretto et al. (2006) found no imitation differences but significant correlations with IFG activity and social ability, but children were not asked to identify the emotions expressed.

Similarly, Hadjikhani et al. (2009) found decreased activity in the insula and amygdala along with the inferior frontal, motor, premotor, temporal, and occipito-temporal cortices in the ASD group compared to TD controls when observing fearful bodily expressions. In addition, participants were less accurate in a separate emotional expression-matching task, suggesting possible links between their emotion perception accuracy and MNS functioning (Hadjikhani et al., 2009). Taken together, results from Hadjikhani et al. (2009) and Dapretto et al. (2006) suggest a link between socioemotional perception and MNS functioning, highlighting earlier suggestions that cognitive rather than automatic, empathic process underlie emotion perception successful social in ASD.

As mentioned, fronto-parietal connectivity is key for MNS functioning (e.g., Buccino et al., 2001), suggesting impairment in this area among children with ASD. Abnormally functioning long-range connections between brain areas, allowing for multiple local signal integration, inter-area communication, and selective attention to specific stimuli needed for emotion perception, have been suggested, possibly stemming from overactive, short-range connections (for review see Belmonte et al., 2004; Courchesne et al., 2007). Indeed, atypical connections have been found in studies on participants with ASD. Nishitani, Avikainen and Hari (2004) recorded participants' magnetoencephalography (MEG) during a simple motor imitation task, and combined them with magnetic resonance imaging (MRI) data to examine the sequence of MNS activations in ASD and TD groups. During imitation, TD controls showed a normal sequence of activation, beginning in the STS then the parietal lobe followed by the frontal area and ending in the motor cortex. The ASD group's activation followed the sequence from the STS to the parietal area, but MNS activation was weaker and delayed past this juncture. In an fMRI study using a modified Tower of London task, Just et al. (2007) demonstrated one long-range frontoparietal connection in TD participants, while the ASD group activated two networks though in increased number of smaller, noncontiguous clusters. Importantly, Just et al. (2007) found significant correlations between low connectivity levels and increased ASD severity. Together, these studies further support MNS dysfunction in ASD, and specifically demonstrate that abnormal connectivity between brain regions may be a critical factor.

In sum, impaired activation in typical MNS areas (e.g., Hadjikhani et al., 2009), possibly stemming from abnormal interconnectivity (e.g., Nishitani, Avikainen, & Hari, 2004), may be at the heart of behavioral deficits in emotional expression recognition and subsequent socioemotional responding (e.g., Philip et al., 2010). Oberman, Winkielman, and Ramachandran's (2007) facial blocking results, in conjunction with widespread motor performance delays in ASD, suggests a possible link to accurate emotional expression perception lies in the ability to perform these expressions. Indeed, Enticott et al. (2012) suggested that MNS dysfunction in ASD may be best understood as a motor performance deficit, as the MNS was located first in motor areas and reflects observation and execution of motor actions. Nevertheless, this possibility awaits further systematic investigation. Dapretto et al. (2006) examined the ability to imitate emotional facial expressions, but did not test their recognition. Conversely, Hadjikhani et al. (2009) assessed participants' emotional bodily expression perception accuracy, but did not assess their ability to produce actions. The current study explored this link by directly examining relationships between motor performance and emotion recognition from facial expression, body posture, and their combination.

Purpose of this Study

To date, research has shown widespread emotional expression perception deficits in ASD. However, evidence has stemmed primarily from studies with facial expressions. TD research indicates bodily expression of emotion alone as a viable source of information sufficient for emotion recognition, while recent findings point to natural emotional expression perception through the combined processing of both the face and body. While interest in emotional bodily expression recognition in ASD is increasing, there have been no explicit within group examinations that compare these two stimulus dimensions and their interrelationship. Likewise, there is little systematic examination of the relationship between motor and social abilities.

The current study sought to add to the extant ASD emotional perception literature by examining expression recognition from nonverbal cues from the face, body, and their combination. Three computerized tasks assessed emotional expression recognition accuracy from facial, bodily, and combined face/body expressions, allowing for direct comparisons of recognition accuracy. Based on previous research indicating a lack of salience for emotional information from faces, it was hypothesized better performance would be seen during tasks, which incorporated bodily expressions. Nevertheless, previous eye-tracking findings have indicated a possible body preference, or at least a lack of preference for core facial emotion areas. Thus, higher accuracy during the body only task versus the combined task was predicted.

A second primary purpose of the current study was to explore possible connections between motor performance and emotional expression perception abilities. MNS-based theories of embodiment suggest that typically, individuals' perceptions of actions observed in others are mapped onto their own neural substrates for those actions, allowing for inferences about another's emotional state and intentions. Subsequent findings have suggested that TD children unconsciously imitate observed actions, and that blocking the ability to imitate decreases accurate perception. This has led some researchers to suggest that MNS dysfunction, and the ability to embody and understand another's actions, can be viewed through motor dysfunction. However, research has yet to explore relationships between accurate recognition of emotional expressions and the innate inability to perform the corresponding actions in ASD. The current study assessed the presence and severity of motor delay via the MABC-2, and correlated results with the previous emotional expression perception performances. It was predicted that participants would show widespread motor delays. Furthermore it was hypothesized that there would be significant relationships between motor performance and emotional expression recognition performance. Moreover, it was predicted that certain motor skills would show stronger relationships with certain emotions, reflecting the differential use of certain movements in one emotion more than another. Additionally, stronger associations were expected between motor performance and emotion recognition from body-only stimuli.

CHAPTER III

METHODS

Participants

Participants were 30 children with ASD (female = 3, male = 27) ranging in age from 70 months to 155 months (*M* = 110.27), taken from the Texas State University summer camp for children with ASD. Participants' scores were included in the analysis if they can (a) understand the task, (b) follow the examiner's directions, and (c) perform the experimental tasks in an engaged manner. Participants' parents provided consent prior to testing. Participants received monetary compensation upon completion of the study. The Institutional Review Board (IRB) at Texas State University approved this study and its procedures.

Stimuli

Three emotion recognition accuracy tasks were assessed by a computerized forced-choice matching tasks presented to the participants via SuperLab 2.0 (Cedrus, San Pedro CA), using static grey scale pictures. Bodily expression photographs used in the body-only, and the face-body task. The actors in the images consisted of five male and five female actors, and were taken from a validated set of photographs, the body expressive action stimulus test (BEAST; de Gelder & Van den Stock, 2011). The BEAST is a validated set of 46 actors modeling 254 whole body expressions with faces obscured. Ten images each of sadness, fear, and happiness were used. Facial stimuli for the face-body tasks were obtained from the widely used and validated set of Ekman pictures of facial affect (Ekman & Friesen, 1976). Ten images each of sadness, fear, and anger, split evenly between male and female actors, were used. The third emotion perception accuracy task (the face-word task) used stimuli developed and used by Baron-Cohen, Wheelwright and Joliffe (1997). Twenty images showing a full female face acting out 10 simple emotions (i.e., happiness, sadness, anger, fear, surprise, disgust, distress with surprise, happiness and anger repeated using new poses) and 10 complex mental states (i.e., scheming, guilt, thoughtful, admiring, quizzical, flirting, bored, interest, and arrogant) were used.

Tasks

To assess motor skills and emotion perception abilities, four tasks were administered. First, the MABC-2 was administered. The MABC-2 is a reliable and valid tool, testing fine and gross motor abilities in three areas: manual dexterity, aiming and catching, and balance. The MABC-2 is designed to accurately assess the absence or presence of motor delay in children ages 3-16 years divided into three age bands: 3-6 years, 7-10 years and 11-16 years. Eight tests are administered, which vary depending on age band. Examples of tests include: throwing and catching a beanbag, threading beads, and balancing on one foot. Participants' raw scores from individual tests within each motor component were added together to produce component scores. Component scores were added together, producing a total test score. This total test score was then used to find a percentile score for each child, using the manual. The MABC-2 utilizes a traffic light scoring system. Children scoring within or below the 5th are in the red zone, indicating significant motor delay, while 5th-15th percentile scores are in the amber zone. These children are at risk for motor delay. All children scoring above the 15th percentile are placed in the green zone, showing no risk for motor delays.

In order to measure emotion perception abilities, participants completed three, forced-choice computerized tasks. Computerized trials were presented in randomized order on a laptop computer, using SuperLab 2.0 software. A fixation screen directing attention to look at the laptop appeared to signal the subsequent presentation of an image, followed by the image itself shortly thereafter. Experimenters calculated overall proportion of correct trials in all three tasks.

In the body-body task, an emotional body expression (sample image) was presented on the computer screen above two bodily expressions, one of which matched the expression seen in the sample. Participants were instructed to choose the expression matching the sample by pressing a specific key on the keyboard corresponding to one of the choices (see Appendix). There was no time limit for responding. A new fixation screen appeared after each response to signal a new trial. After task completion the experimenter computed global accuracy by calculating proportion of correct trials across all 90 trials, as well as individual emotion accuracy for fear, sadness, and happiness.

The second computerized task, face-body task, was very similar except for the sample image. Specifically, an emotional facial expression appeared on the computer screen with two bodily expressions underneath, one of which matched the emotion from the face (see Appendix). Specific keystrokes corresponded to individual bodily expressions, and participants attempted to match one of the bodies to the sample face. A new fixation screen appeared after each keystroke to signal a new trial. There was no time limit for responding. After task completion the experimenter computed global accuracy by calculating proportion of correct trials across all 90 trials, as well as individual emotion accuracy for fear, sadness, and happiness.

The third computerized emotion perception task, the face-word task, used images of an actress expressing facial expressions of either simple emotions or complex mental states taken from the Baron-Cohen, Wheelwright and Joliffe (1997) study. Two labels were located under each image, one of which correctly described the emotion expressed (i.e. “happy” or “sad” underneath a happy face; see appendix). Participants were instructed to choose the label that best described the emotion expressed by pressing the corresponding key. There was no time limit for responding. After each choice, a new image was presented to the participant. After task completion the experimenter computed recognition for simple face-word trials and complex face-word trials.

Procedures

During the month-long summer camp, participants chose a single Friday to complete both the emotion and motor assessment tasks. Motor performance assessments took place in the local school gymnasium, while a nearby classroom was used for computerized testing. During MABC-2 testing, experimenters gave participants oral directions for tasks before physically performing tasks when needed. Participants were allowed practice trials to ensure understanding of the task at hand before scoring. Breaks between tasks and again between tests were given to participants as needed. During the tasks, at least one experimenter observed, while another administered the task. During each test trial, the observing experimenter timed the participant and counted the number of correct responses based on a set of criterion provided by the MABC-2 manual

When participants were not completing the MABC-2, they completed the three emotion perception tasks. The body-body, face-body and face-word tasks were administered on a laptop, running the SuperLab 2.0 (Cedrus, San Pedro CA) software.

Experimenters explained each task to the camper and allowed practice trials to ensure both understanding of the task and that the participant was engaged in the task. When necessary, some participants communicated their choice and the experimenter pressed the corresponding key for the participant. There was no time limit during each trial, but if the camper appeared off-task, the experimenter attempted to redirect the participant's attention back to the screen. Campers were given breaks between each task.

Analysis

One of the primary purposes of this study was to examine differences between emotion recognition abilities as a function of stimulus type (body-only, face-only, face-body). To this end, a one-way repeated measures analysis of variance (ANOVA) was performed with four levels (body-body task, face-body task, simple face-word task, complex face-word task) to compare accuracy across tasks. It was predicted that the body-body task would be most accurate. Post hoc paired sample *t*-tests were conducted to determine any significant differences between tasks. Next, individual emotion accuracy was compared between the body-body and face-body tasks. Due to the inclusion of more emotions and less trials for each emotion, the face-word task was left out of this comparison. A 2 (body-body task, face-body task) x 3 (fear, happiness, sadness) repeated measures ANOVA was performed. Subsequent analysis of main effects and any interaction effects was carried out with Bonferroni adjusted post hoc tests if necessary.

A second objective of the current study was to explore relationships between motor performance and emotional expression recognition. MABC-2 raw scores were used in lieu of percentiles within the analyses. While MABC-2 percentiles are used to determine each participant's zone (i.e., red, amber, green), raw scores were used in the analyses, as they presented a closer approximation of a normal curve. Overall MABC-2 test scores and individual motor component scores (i.e., manual dexterity, aiming and catching, and balance), as well as age were correlated with global recognition scores on the body-body, face-body, simple face-word, complex face-word tasks, as well as recognition of individual emotions on the body-body and face-body tasks, and age in order to determine the presence of any relationships between emotion recognition and motor performance, as well as any effects of age. Significant relationships were predicted between motor performance and accuracy on the body-body and face-body tasks.

Subsequently, where there were significant correlations between MABC-2 scores and emotion recognition, regressions analyses were performed using the motor component scores and age to predict global and individual emotion recognition. This was done because summing up the individual motor component scores produced raw overall MABC-2 scores. Thus, including component scores rather than overall MABC-2 scores lost no information. Furthermore, this allowed for the examination of any differences in the relative contributions of different component motor skills. Lastly, age was included in each regression analyses based off past literature, which has shown TD children have yet to reach adult-like levels of accurate facial expression perception for all simple emotions even by 12-years of age (e.g., Karayanidas, Kelly, Chapman, Mayes, & Johnston 2009). Since this was the oldest age studied, it was important to control for any effects age might have on emotion recognition.

CHAPTER IV

RESULTS

Emotion Recognition Tasks

Mean proportions of correct responses on each emotion perception task are presented along with standard deviations (SD), mean and median reaction times (RT) in Table 1. Cursory examination of the current data suggested higher accuracy for perception of bodily expressions of emotion alone versus perception from other stimuli.

Table 1.
Mean accuracy scores, SD, mean and median reaction times (RT) for all emotion recognition tasks

Task	Mean	SD	Mean RT (ms)	Median RT (ms)
Age	110.3	21		
Body-Body Task				
Fear Perception	.72	.22	4952	4605
Happiness Perception	.74	.25	4960	4166
Sadness Perception	.77	.27	4492	3602
Global Perception	.74	.27	4830	3999
Face-Body Task				
Fear Perception	.70	.24	5097	4481
Happiness Perception	.69	.22	5886	4574
Sadness Perception	.66	.21	3881	3310
Global Perception	.68	.18	5074	4103
Face-Word Task				
Simple Expression Perception	.63	.16	5014	4625
Complex Expression Perception	.61	.21	8327	7280

To determine any global emotion recognition differences, a repeated-measures ANOVA with four levels was carried out to test for main effect of task type. The results indicated there was a main effect of task, $F(3, 87) = 6.30$, $p = .001$, partial $\eta^2 = .178$. Post hoc analysis showed that global body-body perception accuracy was higher compared to global face-body emotion perception accuracy, although this result failed to reach significance: *t(29)* = 1.90, *p* = .067. Global body-body emotion accuracy was significantly higher than simple face-word accuracy, *t(29)* = 3.46, *p* = .002; and complex face-word emotion accuracy, *t(29)* = 4.63, *p* < .001. Global face-body accuracy was not significantly different than simple face-word emotion accuracy, *t(29)* = 1.53, *p* = .138; but failed to reach significance compared to complex facial expression perception, *t(29)* = 1.893, *p* = .068. Lastly, there were no significant differences between simple face-word accuracy and complex face-word accuracy, *t(29)* = .551, *p* = .586.

Following this, a 2 x 3 repeated measures ANOVA was performed, comparing recognition of individual emotions (fear, happiness, sadness) across the body-body and face-body tasks. Results indicated that there was no main effect of task type, *F*(1, 29) = 3.622, *p* = .067, partial η^2 = .111, nor was there a main effect of emotion, *F*(2, 58) = .01, *p* = .99, partial η^2 = .00, nor a significant interaction effect, *F*(2, 58) = .233, *p* = .233, partial η^2 = .049. While all three emotions were generally better recognized during the body-body task, there was no significant difference between recognition accuracy the tasks. Furthermore, sadness was generally recognized best in the body-body task followed by happiness then fear, while this trend was reversed in the face-body task. However, these results indicated there were no significant accuracy differences between emotions within each task (see Table 1).

Motor Performance Results and Relationships with Emotion Recognition

Overall, the vast majority of current participants 96% were in the red zone (delayed). Only four participants (13%) were in the green zone, while the remaining four participants scored in the amber zone. Interestingly, there was a general trend for better motor performance with increased age. Specifically, many of the current participants who scored in the amber and green zones were in the older half of the group (see Table 2). Subsequent analyses used raw MABC-2 total test scores and component scores to analyze relationships with emotion recognition accuracies (see Table 3).

Table 2.

Mean motor performance percentile and traffic-light zone code within each age range tested

Age Range (mo)	*N*	Mean Overall Percentile	Zone Code
60 - 71	2	.3	Red
72 - 83	1	5	Red
84 - 95	4	5	Red
96 - 107	7	7	Amber
108 - 119	5	4	Red
120 - 131	6	20	Green
132 - 143	4	.3	Red
144 - 155	1	50	Green

Note. Red = delayed; amber = at-risk of delay; green = no delay

Table 3.
Mean scores, SD, mean and median RT for all emotion recognition tasks and MABC-2 results

Task	Mean	SD	Mean RT (ms)	Median RT (ms)
Age	110.3	21		
Body-Body Task				
Fear Recognition	.72	.22	4952	4605
Happiness Recognition	.74	.25	4960	4166
Sadness Recognition	.77	.27	4492	3602
Global Recognition	.74	.27	4830	3999
Face-Body Task				
Fear Recognition	.70	.24	5097	4481
Happiness Recognition	.69	.22	5886	4574
Sadness Recognition	.66	.21	3881	3310
Global Recognition	.68	.18	5074	4103
Face-Word Task				
Simple Recognition	.63	.16	5014	4625
Complex Recognition	.61	.21	8327	7280
MABC-2				
Manual Dexterity Score	14.63	9.39		
Aiming & Catching Score	14.63	5.47		
Balance Score	16.57	8.22		
Total Test Score	45.73	19.48		

Planned correlations between global and component MABC-2 motor performance scores and global and individual mean emotion perception accuracies were performed to determine the presence of any relationships (see Table 3). Following this, significant alpha levels were Bonferroni corrected to account for Type I error during regression analyses ($\alpha = .05/10 = .005$). First, accuracy scores from the body-body task were correlated with motor performance results first. Results indicated that overall MABC-2 measures were significantly associated with global body-body accuracy, as well as with accurate fear, happiness, and sadness perception. Age was significantly correlated only with balance performance, indicating this skill increases as children age (see Table 4).

Table 4.
Correlations between global and individual body-body emotion recognition accuracies, age, and MABC-2 total and component scores

Measure	Fear	Happy	Sad	Global	MD	A&C	B	MABC-2	Age
Fear	-								
Happy	.631**	-							
Sad	.658**	.816**	-						
Global	.836**	.917**	.931**	-					
MD	.410*	.422*	.552**	.519**	-				
A&C	.471**	.306	.463*	.459*	.582**	-			
B	.509**	.305	.318	.412*	.487**	.657**	-		
MABC-2	.544**	.418*	.530**	.553**	.851**	.838**	.841**	-	
Age	.359	.336	.193	.324	.154	-.124	.032	.487**	-

Note. MD = manual dexterity; A&C = aiming and catching; B = balance
MABC-2 = MABC-2 total test scores
**. Correlation is significant at the .01 level.
*. Correlation is significant at the .05 level.

Following this, a series of multiple regression analyses was performed using MABC-2 component scores and age to predict global and individual body-body emotion recognition. Because total MABC-2 scores were significantly correlated with global and individual emotion recognition on the body-body task, component MABC-2 test scores were entered as predictors to determine any relative effects of the component motor skills on recognition. Additionally, age was significantly correlated with balance, which added further reason to include age as predictor in the regression models.

Results indicated that the overall model with four predictors (manual dexterity, aiming and catching, balance, and age) could significantly predict global body-body emotion recognition, $R^2 = .484$, $R^2_{adj} = .402$, $F(4, 25) = 5.874$, $p = .002$, accounting for 48% of the variance; and individual sadness recognition, $R^2 = .469$, $R^2_{adj} = .384$, $F(4, 25) = 5.526$, $p = .002$, accounting for 47% of the variance. However, this model could not significantly predict fear recognition, $R^2 = .394$ $R^2_{adj} = .297$, $F(4, 25) = 4.058$, $p = .011$; or happiness recognition, $R^2 = .385$, $R^2_{adj} = .287$, $F(4, 25) = 3.914$, $p = .013$, at the Bonferroni corrected level. Model summaries for global emotion and sadness recognition can be seen in Table 3. Results also indicated that manual dexterity and age were the only significant contributors to these models (see Table 6).

Table 5.

Model summary using MABC-2 component scores and age to predict global and individual sadness body-body emotion recognition

	Global body-body recognition				
	R	*R2*	*R2adj*	*F*	*p*
MD, A&C, B, Age	.696	.484	.402	5.874	.002
	Body-body sadness recognition				
	R	*R2*	*R2adj*	*F*	*p*
MD, A&C, B, Age	.685	.469	.384	5.526	.002

Note: MD = manual dexterity; A&C = aiming and catching; B = balance

Table 6.

Summary of regression coefficients using MABC-2 component scores and age to predict global and individual body-body emotion recognition

	Global body-body recognition				
Predictors	*B*	*SE B*	*β*	*t*	*p*
MD	.013	.005	.561	2.914	.007
A&C	.0144	.009	.357	1.636	.114
B	-.010	.007	-.369	-1.419	.168
Age	.006	.002	.562	2.863	.008

	Sad body-body recognition				
	B	*SE B*	*β*	*t*	*p*
MD	.018	.006	.614	3.144	.004
A&C	.020	.011	.416	1.878	.072
B	-.016	.009	-.496	-1.881	.072
Age	.006	.003	.497	2.498	.019

Note: MD = manual dexterity; A&C = aiming and catching; B = balance

This process was repeated for the face-body task. Accuracy scores from the face-body task were correlated with motor performance results (see Table 7). Results indicated that global MABC-2 measures were significantly associated with global face-body accuracy, as well as with fear, happiness, and sadness recognition. Age was significantly correlated with happiness recognition and balance performance, indicating that these skills increase as children age.

Table 7.
Correlations between global and individual face-body emotion recognition accuracies, age, and MABC-2 total and component scores

Measure	Fear	Happy	Sad	Global	MD	A&C	B	MABC-2	Age
Fear	-								
Happy	.566**	-							
Sad	.513**	.490**	-						
Global	.850**	.828**	.799**	-					
MD	.394*	.338	.315	.424*	-				
A&C	.261	.280	.475**	.406*	.582**	-			
B	.286	.681**	.497**	.584**	.487**	.657**	-		
MABC-2	.384*	.529*	.494**	.565**	.851**	.838**	.841**	-	
Age	.189	.481**	.204	.350	-.124	.032	.487**	.154	-

Note. MD = manual dexterity; A&C = aiming and catching; B = balance
MABC-2 = MABC-2 total test scores
**. Correlation is significant at the .01 level.
*. Correlation is significant at the .05 level.

Following this, a series of multiple regression analyses was performed using MABC-2 component scores and age to predict global and individual face-body emotion recognition. Because total MABC-2 scores were significantly correlated with global and individual emotion recognition on the body-body task, component MABC-2 test scores were entered as predictors to determine any relative effects of the component motor skills on recognition. Additionally, age was significantly correlated with balance, which added further reason to include age as predictor in the regression model.

Results indicated that the overall model with four predictors (manual dexterity, aiming and catching, balance, and age) could significantly predict face-body happiness recognition, $R^2 = .540$, $R^2_{adj} = .467$, $F(4, 25) = 7.342$, $p < .001$, accounting for 54% of the variance. However, this model could not significantly predict global face-body emotion recognition, $R^2 = .396$, $R^2_{adj} = .300$, $F(4, 25) = 4.103$, $p = .011$; fear recognition, $R^2 = .218$, $R^2_{adj} = .093$, $F(4, 25) = 1.746$ $p = .172$; or sadness recognition, $R^2 = .288$ $R^2_{adj} = .175$, $F(4, 25) = 2.534$, $p = .065$, at the Bonferroni corrected level. A model summary for happiness recognition can be seen in Table 8. Results also indicated that balance was the only significant contributor to this model (see Table 9).

Table 8.

Model summary using MABC-2 component scores and age to predict face-body happiness recognition

	Happy face-body recognition				
	R	*R2*	*R2adj*	*F*	*p*
MD, A&C, B, Age	.735	.540	.467	7.342	> .001

Note: MD = manual dexterity; A&C = aiming and catching; B = balance

Table 9.
Summary of regression coefficients using MABC-2 component scores and age to predict face-body happiness recognition

	Happy face-body recognition				
	B	*SE B*	*β*	*t*	*p*
MD	.004	.004	.191	1.052	.303
A&C	-.012	.008	-.293	-1.424	.167
B	.019	.007	.695	2.832	.009
Age	.002	.002	.176	.948	.352

Note: MD = manual dexterity; A&C = aiming and catching; B = balance

Finally, accuracy scores from the face-word tasks were correlated with motor performance results (see Table 10). Results indicated that global MABC-2 measures were significantly associated with complex face-word recognition but not simple face-word recognition. Age was significantly correlated with happiness recognition and balance performance, indicating these skills increase as children age.

Table 10.
Correlations between simple and complex face-word emotion recognition accuracies, age, and MABC-2 total and component scores

Measure	Simple	Complex	MD	A&C	B	MABC-2	Age
Simple	-						
Complex	.435*	-					
MD	.275	.497**	-				
A&C	.304	.494**	.582**	-			
B	.238	.485**	.487**	.657**	-		
MABC-2	.318	.582**	.851**	.838**	.841**	-	
Age	.351	.364*	-.124	.032	.487**	.154	-

Note. MD = manual dexterity; A&C = aiming and catching; B = balance
MABC-2 = MABC-2 total test scores
**. Correlation is significant at the .01 level.
*. Correlation is significant at the .05 level.

Following this, a series of multiple regression analyses was performed using MABC-2 component scores and age to predict complex face-word emotion recognition. Because total MABC-2 scores were significantly correlated with complex face-word emotion recognition, component MABC-2 test scores were entered as predictors to determine any relative effects of the component motor skills on recognition. Additionally, age was significantly correlated with balance and recognition, so this was also entered into the regression models.

Results indicated that the overall model with four predictors (manual dexterity, aiming and catching, balance, and age) could predict complex face-word recognition, $R^2 = .487$, $R^2_{adj} = .405$, $F(4, 25) = 5.934$, $p = .002$, accounting for 49% of the variance. A model summary for happiness recognition is shown in Table 11, wherein manual dexterity and age were the only significant contributors to this model (see Table 12).

Table 11.
Model summary using MABC-2 component scores and age to predict complex face-word emotion recognition

	Complex face-word recognition				
	R	*R2*	*R2adj*	*F*	*p*
MD, A&C, B, Age	.698	.487	.405	5.934	.002

Note: MD = manual dexterity; A&C = aiming and catching;
B = balance

Table 12.
Summary of regression coefficients using MABC-2 component scores and age to predict complex face-word emotion recognition

	Complex face-word recognition				
	B	*SE B*	*β*	*t*	*p*
MD	.010	.004	.467	2.434	.022
A&C	.014	.008	.359	1.650	.111
B	-.006	.006	-.234	-.904	.375
Age	.005	.002	.525	2.682	.013

Note: MD = manual dexterity; A&C = aiming and catching;
B = balance

CHAPTER V

DISCUSSION

Almost 30 years of research have pointed to the presence of emotion recognition deficits in children with ASD. However, the vast majority of this research has focused on facial expressions perception. More recent TD findings suggest that a more accurate understanding of these deficits is incomplete without examining perception of emotional bodily expressions. The limited research available on this topic has demonstrated impairments in emotion recognition in ASD children when viewing both facial and bodily expressions of emotion. Nevertheless, explicit comparisons within children with ASD that compare emotion recognition from faces and bodies are limited. In the current study, 30 children with ASD completed three emotion perception tasks: a body only task, face only task, and combined face-body task. Resulting accuracies were compared to examine differences in recognition as a function of stimulus type.

An additional goal of this study was to examine relationships between emotion recognition and motor abilities. The discovery of an action observation-matching mechanism—the MNS—in monkeys, which is also inferred in humans, suggests that we may decode emotions through embodiment. Specifically, through functional connections between the core frontoparietal MNS network and emotion processing areas, humans may accurately perceive other's emotions through activation of the neural networks involved in feeling these same emotions. Furthermore, this process may involve overtly and automatically mimicking the observed emotional expressions. Given that motor deficits are found in children with ASD, it is possible that these deficits also extend to motor areas subserving the action observation and execution-matching process central to embodiment theory. Therefore, impaired emotional recognition in ASD may be linked to impairments in motor performance. Children in the current study were assessed for motor impairments with the MABC-2. Scores were then correlated with performance on the three emotional expression perception tasks, exploring any relationships between the two. Finally, significant correlations were further analyzed to see if they could predict emotional expression perception accuracy.

Bodily Expression Recognition Performance

Overall, participants with ASD showed 74% recognition accuracy of the emotions from the body-body matching task. Furthermore, participants recognized 77%, 74%, and 72% of the sad, happy, and fearful emotions tested, respectively. These results indicate that expressions can be accurately perceived from the body, supporting previous findings of accurate bodily emotion recognition in ASD (e.g., Atkinson et al., 2004; Sogon & Masutani, 1989; Wallbott, 1998). While these results tend to indicate that current participants are not delayed when recognizing emotional expressions, it is important to note that many participants scored very low around or below 50% accuracy; however some participants scored at ceiling level. In other words, the average score seemingly indicated highly accurate recognition ability in current participants, however, this is most likely due to a small number, scoring at or around 100% accuracy. The majority still showed impairment.

Additionally, differential performance in recognizing individual emotions (fear, happiness, and sadness) was also observed on the body-body matching task. While these findings were not significant in the current study, there is some overlap with previous findings. Specifically, participants more accurately recognized sadness, moderately accurate in recognizing happiness, and least accurate when recognizing fear, converging with previous research. For instance, Van den Stock and de Gelder's (2007) results shared the same profile of behavioral results, which may have resulted from using the both the same stimuli (static, full-light body expressions) and experimental paradigm (two-alternative forced-choice matching) as the current study.

However, Atkinson and colleagues (2004) found a that sadness was most recognized followed by fear then happiness when using full-light, static stimuli of body expressions in a forced-choice labeling paradigm; however, Atkinson also tested bodily expression recognition accuracy across dynamic full- and point-light displays and static full- and point-light displays. Happiness was the most recognized emotion during dynamic and static point-light displays of emotion followed by sadness, while fear was most recognized during dynamic full-light displays with sadness fractionally more accurate than happiness. Previously, Sogon and Masutani (1989) instructed participants to label dynamic full-light expressions, and found that sadness was recognized more accurately than fear, with happiness the least recognized for Japanese participants, while Americans more accurately perceived fear than sadness. In the current study, participants tended to recognize sadness more readily than happiness or fear, mirroring previous TD adult data when using similar stimuli to the current study (e.g., Atkinson et al., 2004; Van den Stock & de Gelder, 2007). It appears that the static versus dynamic nature of stimuli possibly affect which emotions are better recognized. It is entirely possible that a fear may have most recognized if participants viewed dynamic stimuli. Furthermore, it is important to note that previous research typically included many more trials per emotion and may have instructed participants to freely label and or choose the correct label, which could also affect comparisons with current results.

Findings from clinical populations offer a similarly inconsistent recognition profile, regarding differential accuracies among individual emotions. Participants with Huntington's disease and schizophrenia, both of which present motor impairments, have been found to more accurately perceive sadness than fear when tested with similar stimuli and paradigms as the current study (de Gelder et al., 2008; Van den Stock, de Jong, Hodiamont, & de Gelder, 2011). Unfortunately, happy expressions were not tested, so no direct comparisons across emotions can be made. Philip et al. (2010) also used static full-light displays but in a forced-choice labeling design, and found fear most accurately recognized, followed by sadness then happiness in adults with ASD. Conversely, Moore, Hobson, and Lee (1997) found the opposite pattern when children with ASD were asked to freely label dynamic point-light displays. Once again, it appears that differences between current and past findings may stem from stimuli and experimental design.

Moreover, the postural characteristics of each emotion are important to consider as a potential factor for recognition differences. The target emotions consisted of sadness, fear, and happiness, while the choice images consisted of the same emotions plus anger. Sadness is characterized by a forward chest bend and arms down by the side of the body, while anger, fear, and happiness have more up-down arm movements involved and imply more dynamic characteristics. This possibly made it easier to differentiate between sadness and the other emotions in the current study (Coulson, 2004). Furthermore, due to these differences, as well as the stimulus design and procedure—matching bodily expressions rather than labeling the emotions—current participants may have used featural processing to complete the task. Specifically, children in the current study could have matched similar hand and finger placements or arm movements in images as opposed to actually recognizing the emotions presented.

In sum, the children with ASD in the current study accurately matched the majority of sample and target sad, happy, and fearful bodily expressions. While there were no significant accuracy differences, recognition of sadness was highest and fear the lowest. This mirrors earlier research with TD adults when using the same stimuli and design (Van den Stock & de Gelder, 2007); however, studies with different stimuli and procedures have produced different findings and very few have directly tested participants with ASD (Moore, Hobson, & Lee, 1997). Future research needs to address this inconsistency. Furthermore, without a TD control group there it is difficult to judge the level of impairment, if any, of the current participants' recognition accuracy.

Combined Facial and Bodily Expression Recognition Performance

As already noted above, the increased use of body expression stimuli in research has shown that a true understanding of emotion perception may warrant more natural emotional stimuli—faces and bodies together. Specifically, some research has shown that using more ecological stimuli than faces or bodies alone enhances accurate recognition of emotion (Avezier, Trope, & Todorov, 2012; Gunes & Picardi, 2007). For this reason, the face-body expression-matching task was included. Once again, participants performed well, accurately recognizing 68% of the overall face-body task and 65%, 70%, and 69% of the sad, fearful, and happy trials, respectively.

Given the paucity of previous research in this area, combined with the use of different testing procedures and stimuli, comparisons between current and previous findings are difficult. For instance, the current face-body task echoes Hobson (1986b), which showed cross-dimensional emotional recognition deficits, supporting the notion of global emotion perception deficits in ASD. However, angry facial expressions were included in that study, and a five-alternative forced-choice design was used to match drawings of bodily expressions to dynamic recordings of facial expressions. Furthermore, unlike the current study, no significant within-group accuracy differences between emotions were reported in Hobson (1986b), so it impossible to compare any differences in accuracy across the two studies.

In the current study, participants recognized fear marginally better than happiness, while sadness had the lowest accuracy scores. More recent TD findings have shed some light on any possible recognition differences between emotions. Avezier, Trope, and Todorov (2012) tested accurate identification of emotional faces before and after the addition of congruent or incongruent bodies. They found fear to be more recognizable than sadness when faces were presented without bodies, but no difference between emotions when congruent face-body pairings were presented. Unfortunately, happiness was not included in their experiment, further hampering comparisons.

Importantly, they found that both emotions were better recognized when presented with aligned, congruent bodies than alone. This led the authors to suggest that TD individuals perceive bodily and facial emotional expressions holistically rather than as two separate dimensions. This idea was further supported when Avezier, Trope, and Todorov (2012) found significant face-body misalignment, attachment, and incongruency effects on accurate facial emotional expression identification. Specifically, recognition of sad facial expressions was significantly decreased when presented with fearful bodies, while recognition of fearful faces was significantly decreased on angry bodies. Moreover, sad face-angry body combinations were more affected than fearful face-angry body combinations. Additionally, Avezier, Trope, and Todorov (2012) demonstrated that faces, which were unattached and/or misaligned from bodies, were also less accurately recognized than when attached to and aligned with bodies, suggesting that separation causes a further breakdown of holistic emotional expression processing.

These findings are important to the current study for a number of reasons. Current participants may have answered incorrectly due to which bodies were in the sample array, affected by face-body incongruency effects. Furthermore, this effect could have been augmented for sadness since angry bodies were also used in the sample array of the current study. More importantly, the current study may not have been truly tapping into the possible effects that holistically viewing bodies and faces may have on emotion recognition due to misalignment and detachment of faces and bodies. In other words, current participants may have been forced to decode each expression dimension individually then match based off meaning, or possibly match based off the correct "look" of the joined expressions from memory. For instance, recognition of happiness during the face-body task was significantly correlated with age. Happy facial expressions are one of the first emotions TD children perceive (Karayanidas et al., 2009; Vicari, Reilly, Vizzotto, and Caltagirone, 2000), and children with ASD have been shown to be relatively accurate as well (e.g., Castelli, 2005). However, perception of happy bodily expressions alone is relatively difficult for both TD and ASD groups relative to other emotions (e.g., Philip et al., 2010; Sogon & Masutani, 1989). Thus, the ability to match happy facial expressions with happy bodily expressions possibly relies on age-related familiarity with and ability to decode the intended emotion from happy body postures.

In sum, results from the face-body perception task are somewhat unclear in regards to whether the use of more naturally occurring stimuli (i.e., head and body together) affects accurate emotion recognition. This most likely stems from failing to control for any effects of face-body misalignment and detachment, which have been shown to negatively affect holistic processing. Nevertheless, the current results support earlier findings of overall similarity during crossdimensional recognition accuracy between emotions by Hobson (1986b). Without a control group, it is difficult to determine whether current results support earlier findings of expression recognition deficits in ASD. Clearer and more accurate measurement of intended face-body emotion recognition abilities might be gained by matching full face-body composites rather than a bodiless face to faceless bodies. This would ensure that the stimuli are more ecologically valid, and would allow for more accurate examination of holistic versus piecemeal processing in children with ASD.

Simple and Complex Facial Expression Recognition Performance

The current study focused on bodily emotional expressions; however, the simple and complex facial emotion expression task was taken from Baron-Cohen, Wheelwright, and Jolliffe's (1997) study on adults with AS and HFA, warranting, at the very least, comparisons with their study. Current study participants correctly perceived 63% and 61% of the overall simple and complex emotions presented, respectively. Since a very limited number of each emotion stimuli was presented, intra-emotion comparisons and patterns of recognition were not examined.

When compared to Baron-Cohen, Wheelwright, and Jolliffe's (1997) findings, current results indicate much lower perception accuracy in ASD children. Baron-Cohen, Wheelwright, and Jolliffe (1997) found that ASD participants correctly labeled 80% and almost 72% of the simple and complex facial expression, respectively. In addition to scoring much higher than current participants, there was a larger disparity in their scores between simple and complex emotions. However, previous research tested adults with either AS or HFA, while the current study tested children from a wide range of functioning levels. Second, a number of current participants could not read, possibly affecting their performance despite the experimenter reading the options for them. Accordingly, many of the current participants may not have been familiar with the vocabulary for complex emotions prior to testing. This was evident from multiple requests for a definition of these emotions and significant correlations between age and complex facial expression perception. Additionally, TD research has shown that even by age 12, children have yet to reach adult levels of facial expression recognition for simple emotions (e.g., Karayanidas, Kelly, Chapman, Mayes, & Johnston 2009).

Taken together, the current results should be interpreted with caution. Without more exact knowledge of ASD participants' reading ability and functioning level, accurate comparisons with previous ASD findings are tenuous at best. Furthermore, without a control group it is impossible to say whether current ASD participants lag behind their typical peers when presented with this type of assessment. Future research should address these concerns, possibly examining perceptive abilities with a face-face matching task to circumvent differences in verbal ability.

Bodily, Facial, and Combined Emotional Expression Recognition Comparisons

A primary purpose of the current study was to compare recognition of bodily emotional expressions with the other possible stimulus dimensions tested. The initial comparison results tentatively—differences only approached significance between the body-body and face-body tasks—indicate that children with ASD perceive emotions from bodily expressions alone better than facial expressions or combined facial and bodily expressions. Early behavioral studies and recent eye-tracking results offer possible explanations for this increased bodily expression accuracy. Eye-tracking findings have shown that people with ASD attend to social areas of the face less than TD peers, especially the eyes (Pelphrey et al., 2002). Behavioral findings have supported this as well, showing reduced emotion recognition accuracy when only the eyes were present compared to TD controls (Baron-Cohen, Wheelwright, & Jolliffe (1997).

Recently, additional eye-tracking studies have further examined gaze pattern and fixation differences for core emotion areas in the face (e.g., mouth and eyes), as well as the body during observation of socioemotional scenes. Klin et al. (2002) presented film clips to adolescents and adults with and without ASD. They found that the ASD group scanned eyes half as often as TD controls, but they tended to look at the mouth and bodies almost twice as much (Klin et al., 2002). More recently, Fletcher-Watson et al. (2009) compared TD and ASD adult and adolescent groups when viewing social scenes juxtaposed with non-social scenes. Although not significant, they found longer fixations on bodies in the ASD group. Riby and Hancock (2009) examined scanning patterns in adolescents with and without ASD during observation of both dynamic and static human and cartoon social scenes. Results indicated less time spent looking at the face than controls for the ASD group, but more time spent looking at bodies (Riby & Hancock, 2009). Considering these findings, participants in the current study may show superior recognition for bodily expressions of emotion because they inherently attend more to this area. This appears true, as recognition accuracy was greater in both the body-body and face-body tasks compared to the face-word tasks in the current results.

In light of current results, new socioemotional interventions could be possible for children with ASD and other clinical populations presenting emotion recognition deficits. For instance, attempts to augment interpersonal skills could also include bodily expressions as another possible method for decoding other's emotional states. This may prove easier and more successful for children with ASD if they already attend to this area more. Future eye-tracking research could examine possible core socioemotional areas typically scanned from the body analogous to the eye, nose, and mouth regions of the face (e.g., Baron-Cohen, Wheelwright, & Joliffe, 1997; Pelphrey et al., 2002). This could provide a clearer picture regarding any differences between TD and ASD groups during observation of bodily expressions. Regardless, the current data further demonstrates the need for further research of emotion recognition that includes bodily expressions.

Nevertheless, caution is necessary when interpreting these between-task differences. Only three simple emotions—sadness, happiness, and fear—were tested in the body-body and face-body tasks, while six simple emotions—happiness, anger, sadness, fear, surprise, and disgust—were tested in the simple face-word task. Importantly, happiness and sadness are two of the earliest emotional facial expressions to be accurately recognized by TD children, while other emotions like disgust do not reach adult recognition levels until 12 years of age (e.g., Karayanidas, et al., 2009). This is around the age of the oldest current participant. Additionally, the significant correlation between complex face-word performance and age suggests that a valid comparison between the face-word tasks and the other emotion recognition tasks with older participants (with increased exposure to these emotions and their labels) is warranted.

Another point to consider is the heterogeneity of participants in the current study, including varying ASD severity levels, functioning, and verbal abilities. Accordingly, these variations may have affected the successful use of strategies within each task. Specifically, body-body task strategies may have recruited the ability to match similar emotional characteristics such as arm placement or hand manipulations. Conversely, the face-body task possibly required the ability to decode each emotional expression dimension to successfully match each emotional pair, while the face-word tasks required verbal identification abilities to decode emotional expressions as mentioned above.

Minimizing methodological differences across studies may allow for more fluid and accurate between-task comparisons in the future, by requiring similar responses and controlling for the use of different strategies. To illustrate, two-alternative forced-choice matching sample-to-target with the same emotions across the board may reduce the verbal effects inherent to the current face-word task and the differential exposure levels to more complex emotions. Additionally, matching sample composite face-body to composite target stimuli might increase accurate measurement of holistic, face-body emotion perception in ASD, while simultaneously reducing misalignment and detachment effects indicated by Avezier, Trope, and Todorov (2012). Additionally, it is important to note that the absence of time limits may have limited the accuracy of results. Specifically, participants might have simply matched certain features in the target body image with its corresponding image from the array in the body-body task. In other words, participants may not have actually recognized the emotion presented, but may have had intact matching abilities. Subsequent experiments, using different stimuli and time limits, may show different accuracy patterns from the current study, permitting more useful comparisons to be made across studies.

In sum, comparisons between emotion recognition accuracy from facial expressions, bodily expressions, or combined facial and bodily expressions indicated superior perception from bodily expressions. However, methodological differences such as different stimuli or procedures necessitate prudent interpretation, leaving these findings equivocal at the moment. Future research needs to address these concerns and task differences. Likewise, TD research and comparisons with ASD populations are needed to clarify whether these results stem from an innate visual preference for bodies in ASD or are a methodological artifact.

Relationship between Motor Performance and Emotional Expression Recognition

Exploring relationships between emotional expression recognition and motor performance was also central to the current study. Early behavioral findings have shown that adults with ASD showed impairments during accurate recognition of emotional expressions as well as successfully expressing the same emotions (Macdonald et al., 1989). More recently, researchers have theorized that the MNS subserves action understanding wherein the observer is able to embody the observed actions of others. Specifically, these actions, along with their respective meanings and intentions, are understood because they simulated within the observer’s corresponding neural areas, primarily located within a frontoparietal network (e.g., Buccino et al., 2001; Fadiga et al., 1995). Since these areas are involved in action execution as well as observation, it is not surprising that the ability to perform the observed actions may be associated with accurately understanding the actions (e.g., Dimberg, Thunberg & Elmehed, 2000; Oberman, Winkielman, & Ramachandran, 2007).

Current findings appear to support this notion. Seventy-three percent of the current participants were in the red zone, exhibiting motor delays as measured by the MABC-2. Preliminary correlations indicated that global and individual emotion body-body recognition accuracy were significantly correlated with overall MABC-2 motor performance. Additionally, manual dexterity and aiming and catching were significantly correlated with body-body emotion recognition across the board, and balance was significantly related to global emotion and fear recognition. This suggests that the ability to perform the motor movements assessed during the MABC-2 (i.e., manual dexterity, aiming and catching, balance) are all related to accurate recognition of the emotions presented from bodily expression alone in the current study. This is not surprising, considering that the gestures and postures that convey fear, happiness, and sadness involve changes in the postures of the hands and arms, as well as differences in stance and weight transfer.

For instance, Coulson (2004) characterized bodily expressions of fear as consisting of distinct forearm movements and weight transfers, while arms down to the side of the body characterizes sadness, and arms raised above the shoulders and stretched straight out away from the body expresses happiness. Additionally, each bodily expression of emotion used in the current study showed distinct differences with respect to hand directions and closed or opened fingers. Taken together, it makes sense that each component set of movements, and the ability to successfully exhibit these movements, was significantly related to accurate emotion recognition in the body-body task. In other words, because the MNS mediates that ability to recognize emotions by mapping observed actions onto the observer's action execution network, the ability to perform movements that comprise the emotions is related to their accurate recognition.

This study attempted to further explore this relationship via regression models to predict recognition accuracy. Results indicated that the three component motor measures (i.e., manual dexterity, aiming and catching, balance), as well as age, produced a significant predictive model for global body-body emotion and individual sadness recognition. However, only manual dexterity and age were significant contributors to these models. This suggests that deficits in manual dexterity performance adversely affect accurate recognition of bodily expressions. Assuming that the observation of actions activates one's own action execution system, which is mediated by the MNS (e.g., Buccino et al., 2001; Fadiga et al., 1995), and the fact that manual dexterity is involved in the execution of the targeted emotions (e.g., Wallbott, 1998), this result makes intuitive sense. Furthermore, findings have shown that humans automatically mimic observed facial expressions during recognition, and the inability to do so may undermine recognition (e.g., Neal and Chartrand, 2011). However, adolescents and adults with ASD have been shown not to automatically mimic other's facial expressions (e.g., McIntosh et al., 2006), which could be related to MNS dysfunction and possibly extend to bodily expressions of emotion. This is supported by evidence of MNS dysfunction in ASD during emotion-related tasks (e.g., Dapretto et al., 2006; Hadjikhani et al., 2009). Together, it appears that the current results may reflect emotion recognition accuracy as a factor of functional motor performance, and directly related to MNS functioning. This, in turn, supports the initial hypothesis of the current study that without the ability to perform the emotional expressions, one may not be able to accurately recognize them. However, the current study did not examine the ability to pose specific emotional expressions, and assessed motor performance with a standardized assessment tool, which did not provide information about movements associated with emotional states. Therefore, links to the MNS remain an open question. Future research that examines the ability to accurately pose bodily expressions of emotion may help to clarify this issue.

The notion that emotion recognition is linked to MNS function is supported by recent research and the fact that age was also a significant predictor in the body-body regression models. Enticott et al. (2012) posited that MNS dysfunction in ASD may be best understood in terms of motor area dysfunction due to its core action observation-execution matching properties. This is supported by evidence of cortical thinning in these areas by Hadjikhani and colleagues (2006). Importantly, both Enticott et al. (2012) and Hadjikhani et al. (2006) found significant positive relationships between MNS dysfunction and impaired socioemotional skills, while Hilton et al (2007) found similar relationships between motor and social deficits in ASD. Furthermore, Bastiaansen and colleagues (2011) found that MNS activity increased with age, as did social skills. In the current study, age was also a significant predictor of body-body emotion recognition, possibly reflecting increased MNS function and activity. In turn, older age may reflect increased motor cortical functioning, leading to increased motor performance and better emotion recognition. Thus, observed actions may be more readily mapped onto existing areas of proper motor functioning (i.e., manual dexterity) due to increased MNS activity from increased age. Future research is needed to examine these possibilities.

Body-body sadness recognition was also significantly predicted by age and manual dexterity. As already mentioned, hand and finger manipulations are not only involved in each emotion tested here (e.g., Wallbott, 1998), but they are also presented categorically differently in the stimuli. For instance, sadness shows fingers close together and hands resting at the sides of the body. Happiness shows hands raised above the shoulders with palms facing up or in towards the face, while hands facing out away from the body and fingers further apart is characteristic of fear. Additionally, both fear and happiness involve arm movements and imply more dynamic movement, suggesting there is increased chance to confuse the two (e.g., Coulson, 2004; Dael, Mortillaro, & Scherer, 2012). So, it is possible that the ability to perform hand and finger manipulations led to better discrimination between emotions, especially sadness. As mentioned, MNS activity may increase with age (Bastiaansen et al., 2011), thus allowing for better action observation-execution matching in the observer. Evidence suggests that while automatic, accurate facial mimicry is impaired in ASD, accurate, voluntary mimicry is not (e.g., McIntosh et al., 2006). This suggests that age-related increases in MNS functioning may allow for more accurate embodiment, mediated by voluntary mimicry. Indeed, the experimenter noted that some of the older participants in the current study posed a number of the bodily expressions before choosing an answer.

Alternatively, the use of piecemeal strategies may also explain this behavior and in relation to current results. Recent findings have suggested that bodies, like faces, are processed configurally (e.g., Minnebusch, Keune, Suchan, & Daum, 2010). Since children with ASD are known to process faces featurally (e.g., Baron-Cohen, Wheelwright, & Jolliffe, 1997; Pelphrey et al., 2002), it is plausible they may also decode bodies this way, paying closer attention to peripheral rather than core areas. Similarly, acting out hand movements may reflect a piecemeal strategy, which may stem from age-related social adaptations, wherein the participant acts out a movement seen in the array and compares that movement to the above target image. In turn, sadness recognition may reflect this the most due to its characteristically different posturing, especially hands and fingers. Since there was no time limit during emotion recognition trials, this is entirely possible. Children may have been able to accurately match expressions regardless of motor performance abilities. Future research is needed to address this possibility. Specifically, time limits may reduce the ability for participants to match expressions featurally, and may reflect a truer relationship between motor abilities and emotion recognition. Additionally, speech delay is a consistent characteristic in children with ASD, and they are often taught sign language in their early years. Thus, manual dexterity is often part of another form of communication in children with ASD rather than simply another motor skill. This may have contributed to the significant relationships between manual dexterity and emotion recognition seen in the current study. Further eye-tracking and behavioral studies, comparing TD (with and without speech impairments) and ASD groups, are needed to examine typical body scanning patterns during emotion recognition and whether the use of sign language affects the relationship between emotion recognition and specific motor abilities.

Following suit, initial correlations between MABC-2 motor performance scores and global and individual face-body emotion recognition accuracy yielded numerous significant correlations. Considering the use of the same bodily expressions in this task as the body-body task, these results were expected. However, age was also significantly correlated with face-body happiness recognition. As discussed above, this may be a result of stimuli and experimental design. Specifically, congruent-incongruent grouping effects, as well misaligned and detached faces and bodies may have inadvertently increased task difficulty (e.g., Avezier, Trope, & Todorov, 2012), requiring participants to decode each emotion dimension separately or try to match, according to the best which dimensions looked “best” together. In turn, this might have required age-related familiarity with the emotions, especially happiness. While recognition of happy faces has been shown to be relatively accurate in ASD (e.g., Castelli, 2005), happy bodily expressions may be less obviously recognized (e.g., Philip et al., 2010). In sum, the face-body task may not have been tapping into emotion recognition per se. That is, due to the detachment and misalignment effects, this task was not an accurate index of whether or not children with ASD show increased recognition accuracy from ecological stimuli as has been shown in TD participants. Rather, results might have reflected participants’ ability to compensate for these miscellaneous stimuli and design effects.

Subsequent regression analyses, using MABC-2 component scores and age, seem to support this notion. The lack of significant predictive models for global, fear, and sadness face-body recognition suggests that another variable, not measured in the current study, accounts for more of the variance in the recognition of these emotions. Therefore, it may be possible that piecemeal processing or featural recognition is more involved in the face-body task, at least for recognition of global, fearful, and sad face-body emotions. This is partially in line with recent findings by Reed, Nyberg, and Grubb (2012), who found that both visual and embodied expertise are important to body perception. That is, experiences viewing other's bodies help to accurately perceive bodies in the future, while having the ability to perform the movements observed, as mediated by the MNS, also accounts for accurate body perception. However, current results suggest embodied recognition may be engaged differentially for certain emotions. Once again, this may be due to breakdown in holistic perception due to detached and misaligned bodies and faces used in the face-body task that may have promoted featural processing or the use of other strategies (e.g., visual expertise and memory). Future research is needed to address the use of different strategies and processing on emotion recognition from combined face-body stimuli. Specifically, using whole bodies (including faces) may promote the use of configural strategies that are thought to be evoked under normal viewing conditions, which could yield different results from those reported in the currently study.

Nevertheless, regression analysis produced a significant predictive model for recognition of face-body happiness. Moreover, balance was the only significant contributor within the model. One possible explanation of this is that the ability to balance when bodies are presented with faces facilitates accurate discrimination of happiness from other emotions more so than for fear or sadness. However, it is unclear whether this is a factor of embodiment during observation of face-body stimuli in general, or the attempt to compensate for detached and misaligned faces and bodies. For instance, current participants may use balancing abilities to voluntarily mimic aligned happy faces and bodies for accurate matching. As mentioned, the experimenter noticed that some participants moved and adjusted their seating positions during the face-body task, possibly in order to align the best "fit" between expressions. However, research with more naturalistic whole body stimuli is needed, as well as comparisons with TD controls to further examine the effects of balance. Nevertheless, these findings further support the notion that inability to perform the corresponding movements may adversely affect accurate recognition, at least for happiness in the face-body tasks.

Finally, motor performance was correlated with accurate recognition on the simple and complex face-word tasks, and showed no significant correlations between simple face-word performance. Presumably, this is because there are no overlapping muscles or movements used during this task, which are assessed by the MABC-2. Conversely, complex face-word results were significantly correlated with overall and component MABC-2 scores. However, reasons for this are unclear at the moment.

As with the body-body and face-body tasks, a subsequent regression analysis was performed. The results indicated that age and manual dexterity were significant predictors of complex face-word recognition. Previous fMRI findings have indicated similar MNS area activations (e.g., STS, inferior parietal lobe, frontal operculum) in response to both facial expressions, especially the mouth region, and hand gestures (e.g., Iacoboni et al., 1999; Montgomery & Haxby, 2008). Recently, Magnee et al. (2007) found similar facial EMG recordings during perception of happy and fearful facial and bodily expressions. Additionally, children with ASD are often delayed in vocal language, and are taught sign language, suggesting that manual dexterity may be linked to larger communication abilities in current participants than TD children. Together, these findings offer a possible explanation as to why manual dexterity was found to be a significant predictor of complex face-word recognition. Additionally, age was also a significant contributor to the regression model for complex face-word recognition. As stated earlier, even TD children do not show adult-like levels of simple emotion recognition by age 12 (e.g., Karayanidas, Kelly, Chapman, Mayes, & Johnston 2009). Therefore it is safe to assume that many of our participants, who were well under that age, were not familiar with many of the complex emotions tested. Complex emotions may prove a better measure in adults with ASD, who might possess increased conceptual understanding of these emotions compared to children.

CHAPTER VI

CONCLUSION

In conclusion, children with ASD present with a number of diagnostic behaviors. However, socioemotional deficits, namely emotion recognition abilities, have been among the most prominently studied. While recent research has shown that emotions can be accurately recognized from bodily expressions, facial expression stimuli have been used in almost 95% of the extant literature. Moreover, there is a distinct lack of any recognition comparisons between emotional stimulus dimensions in ASD. This study sought to examine these differences.

Current participants attempted to recognize emotions from facial expressions, bodily expressions, or the combination of the two. Subsequent results were compared, examining the presence of accuracy differences as a factor of stimulus dimension. Children with ASD in the current study demonstrated bodily superiority during emotion recognition compared to faces alone and composite face-body stimuli. Recent eye-tracking studies have indicated this may be due to inherent preferences to scan and fixate on bodies relative to typical facial emotional areas such as the eyes in ASD.

However, previous behavioral findings have demonstrated that the manner in which faces and bodies are presented together can negatively affect holistic emotion perception and accurate recognition. Furthermore, the age and heterogeneous makeup of the current participant group possibly affected accurate recognition during the face-word tasks. Specifically, many participants could not read the answer choices, and presumably were unfamiliar with at least some of the simple and complex emotions tested. Future research with more equivalent stimuli might facilitate more fluid comparisons and less equivocal results. Additionally, comparisons with TD controls will better inform whether current results reflect impaired and atypical recognition abilities. Regardless of any shortcomings, current results demonstrate the need for increased focus on bodily expressions within the emotion perception research field to inform better understanding of emotion perception in both TD and clinical populations.

Furthermore, almost 20 years of research on the MNS—a frontoparietal network of neurons that activate during action execution and observation of those same actions—has resulted in a theory of action embodiment to explain emotional expression recognition. Specifically, observed actions, including emotional expressions, are mapped onto the observer's corresponding motor networks. Through functional connections to emotion processing areas, such as the limbic system, the observer then feels these observed emotions, thus facilitating emotion recognition. However, research has increasingly pointed to MNS dysfunction as central to understanding socioemotional deficits in ASD. Because the core of the MNS is located in motor areas, it is possible that motor impairments represent, or at least tap into, corresponding MNS dysfunction. Hence, the action observation-execution matching mechanism, mediated by the MNS, may be disrupted without the ability to perform observed actions.

Guided by this, children in the current study were tested for the presence of motor impairments on the MABC-2, which encompasses manual dexterity, aiming and catching, and balance skills. These movements generally corresponded to the emotional expressions tested in the body only and composite face-body tasks. Not surprisingly, initial correlations demonstrated a number of significant relationships between accurate emotion recognition and functional motor performance. This was further supported by subsequent regression analyses. Certain component motor scores significantly contributed to predictive models for accurate recognition on global bodily expression recognition, as well as recognition of some individual emotions in the body only and composite face-body tasks. These findings tend to support the hypothesis that the ability to perform certain movements required for emotional expressions is significantly related to accurate recognition of those emotions. In addition, comparisons with previous research evidence that this ability is mediated by the MNS. Unexpectedly, motor performance showed a significant relationship with complex face-word recognition. Accordingly, certain component motor scores were significant predictors as reported by regression analysis. Possible reasons for this were not apparent; however, earlier findings have indicated similar neuroanatomical and neurophysiological responses to both facial and bodily expressions.

In spite of this, these findings warrant caution during interpretation. Numerous design issues open the door to confounding variable as the explanation for many of these results. For instance, detaching and misaligning faces and bodies during the face-body task, rather than presenting composite stimuli, possibly affected normal processing and accurate recognition. Additionally, facial recognition tasks required reading ability and familiarity with more complex emotions, which many participants did not possess. Together, it is possible that future research may find different results when controlling for these issues. As such, these data should be seen as more exploratory, guiding future research in this area. However, the potential outcomes of the current study could prove beneficial to the ASD population. The possibility of innate body superiority during emotion recognition may offer improved social skills interventions. Behavior therapy and teaching practices aimed at improving social interaction could also target bodies, which may improve socially adaptive behavior in children and adults with ASD. Furthermore, significant relationships between motor performance and emotion recognition, especially the regressions results, may give further weight for the inclusion of motor skills as a diagnostic criterion. Or, at least, increase its use as an early detection tool. Regardless, it is obvious that bodily expressions are an important and vital dimension within emotion perception research. As such, future theories and directions in this field should be considered incomplete without their examination.

APPENDIX SECTION

Task 1: Campers will choose correct label of emotional body gesture.

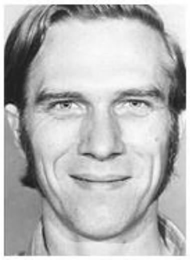
1

2

1

2

Task 2: Campers will match the emotional facial expression with a corresponding bodily emotion.



1

2

1

2

Task 3: Campers will choose correct label of emotional facial expression.

Happy 1

Sad 2

REFERENCES

Adolphs, R. (2001). The neurobiology of social cognition. *Current Opinion in Neurobiology*, *11*(2), 231-239. doi:10.1016/S0959-4388(00)00202-6

Adolphs, R., Sears, L., & Piven, J. (2001). Abnormal processing of social information from faces in autism. *Journal of Cognitive Neuroscience*, *13*(2), 232-240. doi:10.1162/089892901564289

Adolphs, R., Tranel, D., & Damasio, A. R. (1998). The human amygdala in social judgment. *Nature*, *393*(6684), 470-474. doi:10.1038/30982

Allen, G., & Courchesne, E. (2003). Differential Effects of Developmental Cerebellar Abnormality on Cognitive and Motor Functions in the Cerebellum: An fMRI Study of Autism. *American Journal of Psychiatry*, *160*, 262-273. Retrieved from http://ajp.psychiatryonline.org

American Psychiatric Association. American Psychiatric Association. DSM-5 Task Force (2013). *Diagnostic and statistical manual of mental disorders: DSM-5*. Washington, D.C: American Psychiatric Association.

Apraxia Information Page: National Institute of Neurological Disorders and Stroke (NINDS). (2014). Retrieved from http://www.ninds.nih.gov/disorders/apraxia/apraxia.htm#Is_there_any_treatment

Atkinson, A. P. (2009). Impaired recognition of emotions from body movements is associated with elevated motion coherence thresholds in autism spectrum disorders. *Neuropsychologia*, *47*(13), 3023-3029. doi:10.1016/j.neuropsychologia.2009.05.019

Atkinson, A. P., Dittrich, W. H., Gemmell, A. J., & Young, A. W. (2004). Emotion perception from dynamic and static body expressions in point-light and full-light displays. *Perception*, *33*(6), 717-746. doi:10.1068/p5096

Aviezer, H., Trope, Y., & Todorov, A. (2012). Holistic person processing: Faces with bodies tell the whole story. *Journal of Personality and Social Psychology*, *103*(1), 20-37. doi:10.1037/a0027411

Bal, E., Harden, E., Lamb, D., Hecke, A. V., Denver, J. W., & Porges, S. W. (2010). Emotion Recognition in Children with Autism Spectrum Disorders: Relations to Eye Gaze and Autonomic State. *Journal of Autism and Developmental Disorders*, *40*(3), 358-370. doi:10.1007/s10803-009-0884-3

Baron-Cohen, S., Wheelwright, S., & Jolliffe, T. (1997). Is there a "Language of the Eyes"? Evidence from normal adults, and adults with autism or asperger syndrome. *Visual Cognition*, *4*(3), 311-331. doi:10.1080/713756761

Bastiaansen, J. A., Thioux, M., Nanetti, L., Gaag, C. V., Ketelaars, C., Minderaa, R., & Keysers, C. (2011). Age-related increase in inferior frontal gyrus activity and social functioning in autism spectrum disorder. *Biological Psychiatry*, *69*(9), 832-838. doi:10.1016/j.biopsych.2010.11.007

Batty, M., & Taylor, M. J. (2003). Early processing of the six basic facial emotional expressions. *Cognitive Brain Research*, *17*(3), 613-620. doi:10.1016/S0926-6410(03)00174-5

Begeer, S., Rieffe, C., Terwogt, M. M., & Stockmann, L. (2006). Attention to facial emotion expressions in children with autism. *Autism*, *10*(1), 37-51. doi:10.1177/1362361306057862

Belmonte, M. K., & Yurgelun-Todd, D. A. (2004). Functional anatomy of impaired selective attention and compensatory processing in autism. *Cognitive Brain Research*, *17*, 651-664. doi:10.1016 /S0926-6410(03)00189-7

Bolte, S., & Poustka, F. (2003). The recognition of facial affect in autistic and schizophrenic subjects and their first-degree relatives. *Psychological Medicine*, *33*(5), 907-915. doi:10.1017/S0033291703007438

Boone, R. T., & Cunningham, J. G. (1998). Children's decoding of emotion in expressive body movement: The development of cue attunement. *Developmental Psychology*, *34*(5), 1007-1016. doi:10.1037//0012-1649.34.5.1007

Braverman, M., Fein, D., Lucci, D., & Waterhouse, L. (1989). Affect comprehension in children with pervasive developmental disorders. *Journal of Autism and Developmental Disorders*, *19*(2), 301-316. doi:10.1007/BF02211848

Buccino, G., Binkofski, F., Fink, G. R., Fadiga, L., Fogassi, L., Gallese, V., . . . Freund, H. (2001). Action observation activates premotor and parietal areas in a somatotopic manner: an fMRI study. *European Journal of Neuroscience*, *13*(2), 400-404. doi:10.1111/j.1460-9568.2001.01385.x

Buisine, S., Courgeon, M., Charles, A., Clavel, C., Martin, J., Tan, N., & Grynszpan, O. (2014). The role of body postures in the recognition of emotions in contextually rich scenarios. *International Journal of Human-Computer Interaction*, *30*(1), 52-62. doi:10.1080/10447318.2013.802200

Carr, L., Iacoboni, M., Dubeau, M., Mazziotta, J. C., & Lenzi, G. L. (2003). Neural mechanisms of empathy in humans: A relay from neural systems for imitation to limbic areas. *Proceedings of The National Academy of Sciences*, *100*(9), 5497-5502. doi:10.1073/pnas.0935845100

Castelli, F. (2005). Understanding emotions from standardized facial expressions in autism and normal development. *Autism*, *9*(4), 428-449. doi:10.1177/1362361305056082

Celani, G., Battacchi, M. W., & Arcidiacono, L. (1999). The Understanding of the Emotional Meaning of Facial Expressions in People with Autism. *Journal of Autism and Developmental Disorders*, *29*(1), 57-66. doi:10.1023/A:1025970600181

CDC | Data and Statistics | Autism Spectrum Disorder (ASD) | NCBDDD. (2014). Retrieved from http://www.cdc.gov/ncbddd/autism/data.html

Celani, G., Battacchi, M. W., & Arcidiacono, L. (1999). The Understanding of the Emotional Meaning of Facial Expressions in People with Autism. *Journal of Autism and Developmental Disorders*, *29*(1), 57-66. doi:10.1023/A:1025970600181

Cermak, S., Coster, W., & Drake, C. (1980). Representational and nonrepresentational gestures in boys with learning disabilities. *American Journal of Occupational Therapy*, *34*, 19-26.

Coulson, M. (2004). Attributing emotion to static body postures: Recognition accuracy, confusions, and viewpoint dependence. *Journal of Nonverbal Behavior*, *28*(2), 117-139. doi:10.1023/B:JONB.0000023655.25550.be

Courchesne, E., Pierce, K., Schumann, C. M., Redcay, E., Buckwalter, J. A., Kennedy, D. P., & Morgan, J. (2007). Mapping early brain development in autism. *Neuron*, *56*(2), 399-413. doi:10.1016/j.neuron.2007.10.016

Critchley, H. D., Daly, E. M., Bullmore, E. T., Williams, S., Van Amelsvoort, T., Robertson, D. M., Rowe, A., Phillips, M., McAlonan, G., Howlin, P., & Murphy, D. M. (2000). The functional neuroanatomy of social behaviour: Changes in cerebral blood flow when people with autistic disorder process facial expressions. *Brain*, *123*, 2203-2212.

Cummins, A., Piek, J. P., & Dyck, M. J. (2005). Motor coordination,empathy, and social behaviour in school-aged children. *Developmental Medicine & Child Neurology*, *47*, 437–442.

Dael, N., Mortillaro, M., & Scherer, K. R. (2012). Emotion Expression in body action and posture. *Emotion*, *12*(5), 1085-1101. doi:0.1037/a0025737

Dael, N., Mortillaro, M., & Scherer, K. R. (2012). The body action and posture coding system (BAP): Development and reliability. *Journal of Nonverbal Behavior*, *36*, 97-121. doi:10.1007/s10919-012-0130-0

Dapretto, M., Davies, M., Pfeifer, J., Scott, A., Sigman, M., Bookheimer, S., & Iacoboni, M. (2005). Understanding emotions in others: Mirror neuron dysfunction in children with autism spectrum disorders. *nature neuroscience*, 1-3. doi:10.1038/nn1611

Dawson, G., Toth, K., Abbott, R., Osterling, J., Munson, J., Estes, A., & Liaw, J. (2004). Early Social Attention Impairments in Autism: Social Orienting, Joint Attention, and Attention to Distress. *Developmental Psychology*, *40*(2), 271-283. doi:10.1037/0012-1649.40.2.271

Dawson, G., Webb, S. J., & McPartland, J. (2005). Understanding the nature of face processing impairment in autism: Insights from behavioral and electrophysiological studies. *Developmental Neuropsychology*, *27*(3), 403-424. doi:10.1207/s15326942dn2703_6

De Gelder, B. (2009). Why bodies? Twelve reasons for including bodily expressions in affective neuroscience. *Phil. Trans. R. Soc. B*, *364*, 3475-3484. doi:10.1098/rstb.2009.0190

De Gelder, B., Den Stock, J. V., Balaguer, R. D., & Bachoud-L_vi, A. (2008). Huntington's disease impairs recognition of angry and instrumental body language. *Neuropsychologia*, *46*(1), 369-373. doi:10.1016/j.neuropsychologia.2007.10.015

Dimberg, U., Thunberg, M., & Elmehed, K. (2000). Unconscious facial reactions to emotional facial expressions. *Psychological Science*, *11*(1), 86-89. doi:10.1111/1467-9280.0022

Di Pellegrino, G., Fadiga, L., Fogassi, L., Gallese, V., & Rizzolatti, G. (1992). Understanding motor events: a neurophysiological study. *Exp Brain Res*, *91*(1), 176-180.

Enticott, P. G., Johnston, P. J., Herring, S. E., Hoy, K. E., & Fitzgerald, P. B. (2008). Mirror neuron activation is associated with facial emotion processing. *Neuropsychologia*, *46*, 2851-2854. doi:10.1016/j.neuropsychologia.2008.04.022

Enticott, P. G., Kennedy, H. A., Rinehart, N. J., Tonge, B. J., Bradshaw, J. L., Taffe, J. R., . . . Fitzgerald, P. B. (2012). Mirror neuron activity associated with social impairments but not age in autism spectrum disorder. *Biological Psychiatry*, *71*(5), 427-433. doi:10.1016/j.biopsych.2011.09.001

Fadiga, L., Fogassi, L., Pavesi, G., & Rizzolatti, G. (1995). Motor Facilitation during action observation: A magnetic stimulation study. *Journal of Neuropsychology*, *73*(6).

Fletcher-Watson, S., Leekam, S. R., Benson, V., Frank, M. C., & Findlay, J. M. (2009). Eye-movements reveal attention to social information in autism spectrum disorder. *Neuropsychologia*, *47*(1), 248-257. doi:10.1016/j.neuropsychologia.2008.07.016

Fogel, A. (1992). Movement and communication in human infancy: The social dynamics of development. *Human Movement Science*, *11*, 387-423. doi:10.1016/0167-9457(92)90021-3

Fogel, A., Nwokah, E., Dedo, J. Y., Messinger, D., Dickson, K. L., Matusov, E., & Holt, S. A. (1992). Social process theory of emotion: A dynamic systems approach. *Social Development*, *1*(2), 122-142. doi:10.1111/j.1467-9507.1992.tb00116.x

Gallese, V., Fadiga, L., Fogassi, L., & Rizzolatti, G. (1996). Action recognition in the premotor cortex. *Brain*, *119*, 593-609. doi:10.1093/brain/119.2.593

Gallese, V., Keysers, C., & Rizzolatti, G. (2004). A unifying view of the basis of social cognition. *Trends in Cognitive Sciences*, *8*(9). doi:10.1016/j.tics.2004.07.002

Gelder, B. D., Stock, J. V., Balaguer, R. D., & Bachoud-L_vi, A. (2008). Huntington's disease impairs recognition of angry and instrumental body language. *Neuropsychologia*, *46*(1), 369-373. doi:10.1016/j.neuropsychologia.2007.10.015

Green, D., Baird, G., Barnett, A. L., Henderson, L., Huber, J., & Henderson, S. E. (2002). The severity and nature of motor impairment in Asperger's syndrome: a comparison with Specific Developmental Disorder of Motor Function. *Journal of Child Psychology and Psychiatry*, *43*, 655-668. doi:10.1111/1469-7610.00054

Grèzes, J., & De Gelder, B. (2009). Social perception: understanding other people’s intentions and emotions through their actions. In T. Striano & V. Reid (Eds.), *Social cognition: Development, neuroscience, and autism* (pp. 67-78). Chichester, UK: Wiley-Blackwell.

Grèzes, J., Pichon, S., & Gelder, B. D. (2007). Perceiving fear in dynamic body expressions. *Neuroimage*, *35*(2), 959-967. doi:10.1016/j.neuroimage.2006.11.030

Grezes, J., Wicker, B., Berthoz, S., & De Gelder, B. (2009). A failure to grasp the affective meaning of actions in autism spectrum disorder subjects. *Neuropsychologia*. doi: 10.1016/j.neuropsychologia.2009.02.021.

Gunes, H., & Piccardi, M. (2007). Bimodal emotion recognition from expressive face and body gestures. *Journal of Network and Computer Applications*, *30*(4), 1334-1345. doi:10.1016/j.jnca.2006.09.007

Hadjikhani, N., Joseph, R. M., Snyder, J., & Tager-Flusberg, H. (2006). Anatomical differences in the mirror neuron system and social cognition network in autism. *Cerebral Cortex*, *16*(9), 1276-1282.

Hadjikhani, N., Joseph, R. M., Manoach, D. S., Naik, P., Snyder, N., Dominick, K., . . . Gelder, B. D. (2009). Body expressions of emotion do not trigger fear contagion in autism spectrum disorder. *Social Cognitive and Affective Neuroscience*, *4*(1), 70-78.

Harms, M. B., Martin, A., & Wallace, G. L. (2010). Facial emotion recognition in autism spectrum disorders: A review of behavioral and neuroimaging studies. *Neuropsychology Review*, *20*, 290-322. doi:10.1007/s11065-010-9138-6

Hatice, G., Maja, P., & Massimo, P. (2008). From the Lab to the Real World: Affect Recognition Using Multiple Cues and Modalities. In *Affective computing: focus on emotion expression, synthesis, and recognition* (pp. 185-218). Vienna, Austria: INTECH Open Access Publisher.

Haxby, J. V., Hoffman, E. A., & Gobbini, M. I. (2000). The distributed human neural system for face perception. *Trends in Cognitive Sciences*, *4*(6), 223-233. doi:10.1016/S1364-6613(00)01482-0

Haxby, J. V., Hoffman, E. A., & Gobbini, M. I. (2002). Human neural systems for face recognition and social communication. *Biological Psychiatry*, *51*(1), 59-67. doi:10.1016/S0006-3223(01)01330-0

Henderson, S. E., Sugden, D., Barnett, A. L., & Harcourt Assessment. (2007). *Movement Assessment Battery for Children-2* (2nd ed.). London, U.K.: Harcourt Assessment.

Hilton, C., Graver, K., & LaVesser, P. (2007). Relationship between social competence and sensory processing in children with high functioning autism spectrum disorders. *Research in Autism Spectrum Disorders*, *1*(2), 164-173. doi:10.1016/j.rasd.2006.10.002

Hobson, R. P. (1986a). The autistic child's appraisal of expressions of emotion. *Journal of Child Psychology and Psychiatry*, *27*(3), 321-342. doi:10.1111/j.1469-7610.1986.tb01836.x

Hobson, R. P. (1986b). The autistic child's appraisal of expressions of emotion: A further study. *Journal of Child Psychology and Psychiatry*, *27*(5), 671-680. doi:10.1111/j.1469-7610.1986.tb00191.x

Hobson, R. P. (1987). The salience of facial expression for autistic children. *Journal of Child Psychology and Psychiatry*, *28*(1), 137-152. doi:10.1111/j.1469-7610.1987.tb00658.x

Hobson, R. P., Ouston, J., & Lee, A. (1988). What's in a face? The case of autism. *British Journal of Psychology*, *79*(4), 441-453. doi:0.1111/j.2044-8295.1988.tb02745.x

Hubert, B., Wicker, B., Moore, D. G., Monfardini, E., Duverger, H., Fonséca, D. D., & Deruelle, C. (2007). Brief report: Recognition of emotional and non-emotional biological motion in individuals with autistic spectrum disorders. *Journal of Autism and Developmental Disorders*, *37*(7), 1386-1392. doi:10.1007/s10803-006-0275-y

Hypotonia Information Page: National Institute of Neurological Disorders and Stroke (NINDS). (2014). Retrieved from http://www.ninds.nih.gov/disorders/hypotonia/hypotonia.htm

Iacoboni, M., Molnar-Szakacs, I., Gallese, V., Buccino, G., Mazziotta, J. C., & Rizzolatti, G. (2005). Grasping the intentions of others with one's own mirror neuron system. *PLOS Biology*, *3*(3). doi:10.1371/journal.pbio.0030079.st005

Iacoboni, M., Woods, R. P., Brass, M., Bekkering, H., Mazziotta, J. C., & Rizzolatti, G. (1999). Cortical mechanisms of human imitation. *Science*, *286*, 2526-2528. doi:10.1126/science.286.5449.2526

Jansiewicz, E. M., Goldberg, M. C., Newschaffer, C. J., Denckla, M. B., Landa, R., & Mostofsky, S. H. (2006). Motor signs distinguish children with high functioning autism and asperger?s syndrome from controls. *Journal of Autism and Developmental Disorders*, *36*(5), 613-621. doi:10.1007/s10803-006-0109-y

Joyce, C., & Rossion, B. (2005). The face-sensitive N170 and VPP components manifest the same brain processes: The effect of reference electrode site. *Clinical Neurophysiology*, *116*(11), 2613-2631. doi:10.1016/j.clinph.2005.07.005

Just, M. A., Cherkassky, V. L., Keller, T. A., Kana, R. K., & Minshew, N. J. (2007). Functional and anatomical cortical underconnectivity in autism: Evidence from an fMRI study of an executive function task and corpus callosum morphometry. *Cerebral Cortex*, *17*, 951-961. doi:10.1093/cercor/bhl006

Kanner, L. (1943). Autistic disturbances of affective contact. *Nervous Child*, *2*, 217-250.

Karayanidis, F., Kelly, M., Chapman, P., Mayes, A., & Johnston, P. (2009). Facial identity and facial expression matching in 5-12-year-old children and adults. *Infant and Child Development*, *18*, 404-421. doi:10.1002/icd.615

Klin, A., Jones, W., Schultz, R., Volkmar, F., & Cohen, D. (2002). Visual fixation patterns during viewing of naturalistic social situations as predictors of social competence in individuals with autism. *Archives of General Psychiatry*, *59*(9), 809-816. doi:10.1001/archpsyc.59.9.809

Lepage, J., & Th_oret, H. (2006). EEG evidence for the presence of an action observation-execution matching system in children. *European Journal of Neuroscience*, *23*(9), 2505-2510. doi:10.1111/j.1460-9568.2006.04769.x

Leslie, K. R., Johnson-Frey, S. H., & Grafton, S. T. (2004). Functional imaging of face and hand imitation: towards a motor theory of empathy. *Neuroimage*, *21*(2), 601-607. doi:10.1016/j.neuroimage.2003.09.038

Linkenkaer-Hansen, K., Palva, J. M., Sams, M., Hietanen, J. K., Aronen, H. J., & Ilmoniemi, R. J. (1998). Face-selective processing in human extrastriate cortex around 120 ms after stimulus onset revealed by magneto- and electroencephalography. *Neuroscience Letters*, *253*(3), 147-150. doi:10.1016/S0304-3940(98)00586-2

Liu, T. (2012). Motor milestone development in young children with autism spectrum disorders: an exploratory study. *Educational Psychology in Practice*, *28*, 315-326. doi:10.1080/02667363.2012.684340

Liu, T., & Breslin, C. (2013). The effect of a picture activity schedule on performance of the MABC-2 for children with autism spectrum disorder. *Research Quarterly for Exercise and Sport*, *84*(2), 206-212.

Liu, T., & Breslin, C. M. (2013). Fine and gross motor performance of the MABC-2 by children with autism spectrum disorder and typically developing children. *Research in Autism Spectrum Disorders*, *7*(10), 1244-1249. doi:10.1016/j.rasd.2013.07.002

Liu, T., Hamilton, M., Davis, L., & El Garhy, S. (2014). Gross motor performance by children with autism spectrum disorder and typically developing children on TGMD-2. *Journal of Child & Adolescent Behavior*, *2*(123). doi:10.4172/jcalb.1000123

Lloyd, M., MacDonald, M., & Lord, C. (2013). Motor skills of toddlers with autism spectrum disorders. *Autism*, *17*(2), 133-146. doi:10.1177/1362361311402230

Lord, C., Rutter, M., & Couteur, A. (1994). Autism Diagnostic Interview-Revised: A revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders. *Journal of Autism and Developmental Disorders*, *24*(5), 659-685. doi:10.1007/BF02172145

Macdonald, H., Rutter, M., Howlin, P., Rios, P., Conteur, A. L., Evered, C., & Folstein, S. (1989). Recognition and expression of emotional cues by autistic and normal adults. *Journal of Child Psychology and Psychiatry*, *30*(6), 865-877. doi:10.1111/j.1469-7610.1989.tb00288.x

Magnee, M., Stekelenburg, J. J., Kemner, C., & De Gelder, B. (2007). Similar facial electromyographic responses to faces, voices, and body expressions. *Cognitive neuroscience and neuropsychology*, *18*(4). doi:10.1097/WNR.0b013e32801776e6

Matson, M. L., Matson, J. L., & Beighley, J. S. (2011). Comorbidity of physical and motor problems in children with autism. *Research in Developmental Disabilities*, *32*(6), 2304-2308. doi:10.1016/j.ridd.2011.07.036

McIntosh, D. N., Reichmann-Decker, A., Winkielman, P., & Wilbarger, J. L. (2006). When the social mirror breaks: deficits in automatic, but not voluntary, mimicry of emotional facial expressions in autism. *Developmental Science*, *9*(3), 295-302. doi:10.1111/j.1467-7687.2006.00492.x

Meeren, H. K., Van Heijnsbergen, C., & De Gelder, B. (2005). Rapid perceptual integration of facial expression and emotional body language. *PNAS*, *102*(45). Retrieved from www.pnas.orgcgidoi10.1073pnas.0507650102

Ming, X., Brimacombe, M., & Wagner, G. C. (2007). Prevalence of motor impairment in autism spectrum disorders. *Brain & Development*, *29*(9), 565-570. doi:10.1016/j.braindev.2007.03.002

Minnebusch, D. A., Keune, P. M., Suchan, B., & Daum, I. (2010). Gradual inversion affects the processing of human body shapes. *Neuroimage*, *49*(3), 2746-2755. doi:10.1016/j.neuroimage.2009.10.046

Miyahara, M., Tsujii, M., Hori, M., Nakanishi, K., Kageyama, H., & Sugiyama, T. (1997). Brief report: motor incoordination in children with asperger syndrome and learning disabilities. *Journal of Autism and Developmental Disorders*, *27*(5), 595-603. doi:10.1023/A:1025834211548

Montgomery, K. J., & Haxby, J. V. (2008). Mirror neuron system differentially activated by facial expressions and social hand gestures: A functional magnetic resonance Imaging study. *Journal of Cognitive Neuroscience*, *20*(10), 1866-1877. doi:10.1162/jocn.2008.20127

Moore, D. G., Hobson, R. P., & Lee, A. (1997). Components of person perception: An investigation with autistic, non-autistic retarded and typically developing children and adolescents. *British Journal of Developmental Psychology*, *15*, 401-423. Retrieved from http://dx.doi.org/10.1111/j.2044-835X.1997.tb00738.x

Moran, M. A., Mufson, E. J., & Mesulam, M. (1987). Neural inputs into the temporopolar cortex of the rhesus monkey. *Journal of Comparative Neurology*, *256*(1), 88-103. doi:10.1002/cne.902560108

Mundy, P., Sigman, M., Ungerer, J., & Sherman, T. (1986). Defining the social deficits of autism: The contribution of non-verbal communication measures. *Journal of Child Psychology and Psychiatry*, *27*(5), 657-669. doi:10.1111/j.1469-7610.1986.tb00190.x

Neal, D. T., & Chartrand, T. L. (2011). Embodied emotion perception: Amplifying and dampening facial feedback modulates emotion perception accuracy. *Social Psychological and Personality Science*, *2*(6), 673-678. doi:0.1177/1948550611406138

Nishitani, N., Avikainen, S., & Hari, R. (2004). Abnormal imitation-related cortical activation sequences in Asperger's syndrome. *Annals of Neurology*, *55*(4), 558-562. doi:10.1002/ana.20031

Oberman, L. M., Winkielman, P., & Ramachandran, V. S. (2007). Face to face: Blocking facial mimicry can selectively impair recognition of emotional expressions. *Social Neuroscience*, *2*(3-4), 167-178. doi:10.1080/17470910701391943

Pelphrey, K. A., Morris, J. P., McCarthy, G., & LaBar, K. S. (2007). Perception of dynamic changes in facial affect and identity in autism. *Social Cognitive and Affective Neuroscience*, *2*(2), 140-149. doi:10.1093/scan/nsm010

Pelphrey, K. A., Sasson, N. J., Reznick, J. S., Paul, G., Goldman, B. D., & Piven, J. (2002). Visual scanning of faces in autism. *Journal of Autism and Developmental Disorders*, *32*(4), 249-261. doi:10.1023/A:1016374617369

Philip, R. C., Whalley, H. C., Stanfield, A. C., Sprengelmeyer, R., Santos, I. M., Young, A. W., . . . Lawrie, S. M. (2010). Deficits in facial, body movement and vocal emotional processing in autism spectrum disorders. *Psychological Medicine*, *40*(11), 1919-1929. doi:10.1017/S0033291709992364

Piek, J. P., & Dyck, M. J. (2004). Sensory-motor deficits in children with developmental coordination disorder, attention deficit hyperactivity disorder and autistic disorder. *Human Movement Science*, *23*(3-4), 475-488. doi:10.1016/j.humov.2004.08.019

Provost, B., Heimerl, S., & Lopez, B. (2007). Levels of gross and fine motor development in young children with autism spectrum disorder. *Physical & Occupational Therapy in Pediatrics*, *27*(3), 21-36. doi:10.1300/J006v27n03_03

Reed, C. L., Nyberg, A. A., & Grubb, J. D. (2012). Contributions of visual and embodied expertise to body perception. *Perception*, *41*, 439-446. doi:10.1068/p7029

Riby, D. M., & Hancock, P. J. (2009). Do faces capture the attention of individuals with williams syndrome or autism? Evidence from tracking eye movements. *Journal of Autism and Developmental Disorders*, *39*, 421-431. doi:10.1007/s10803-008-0641-z

Rinehart, N. J., Bellgrove, M. A., Tonge, B. J., Brereton, A. V., Howells-Rankin, D., & Bradshaw, J. L. (2006). An Examination of Movement Kinematics in Young People with High-functioning Autism and Asperger's Disorder: Further Evidence for a Motor Planning Deficit. *J Autism Dev Disord*, *36*(6), 757-767. doi:10.1007/s10803-006-0118-x

Rizzolatti, G., Fadiga, L., Gallese, V., & Fogassi, L. (1996). Premotor cortex and the recognition of motor actions. *Cognitive Brain Research*, *3*(2), 131-141. doi:10.1016/0926-6410(95)00038-0

Salovey, P., & Mayer, J. D. (1989). Emotional intelligence. *Imagination, Cognition, and Personality*, *9*(3), 185-211. doi:10.2190/DUGG-P24E-52WK-6CDG

Schultz, R. T., Gauthier, I., Klin, A., Fulbright, R. K., Anderson, A. W., Volkmar, F., . . . Gore, J. C. (2000). Abnormal ventral temporal cortical activity during face discrimination among individuals with autism and asperger syndrome. *Archives of General Psychiatry*, *57*(4), 331-340. doi:10.1001/archpsyc.57.4.331

Shallice, T. (2001). `Theory of mind' and the prefrontal cortex. *Brain*, *124*(2), 247-248. doi:10.1093/brain/124.2.247

Sogon, S., & Masutani, M. (1989). Identification of emotion from body movements: A cross-cultural study of Americans and Japanese. *Psychological Reports*, *65*, 35-46. doi:10.2466/pr0.1989.65.1.35

Stekelenburg, J. J., Kemner, C., & Gelder, B. D. (2007). Similar facial electromyographic responses to faces, voices, and body expressions. *Neuroreport*, *18*(4), 369-372. doi:10.1097/WNR.0b013e32801776e6

Stock, J. V., Jong, S. J., Hodiamont, P. P., & Gelder, B. D. (2011). Perceiving emotions from bodily expressions and multisensory integration of emotion cues in schizophrenia. *Social Neuroscience*, *6*(5-6), 537-547. doi:10.1080/17470919.2011.568790

Stuss, D. T., & Levine, B. (2002). Adult clinical neuropsychology: Lessons from studies of the frontal lobes. *Annual Review of Psychology*, *53*(1), 401-433. doi:10.1146/annurev.psych.53.100901.135220

Tantam, D., Monaghan, L., Nicholson, H., & Stirling, J. (1989). Autistic Children's Ability to Interpret Faces: A Research Note. *Journal of Child Psychology and Psychiatry*, *30*(4), 623-630. doi:10.1111/j.1469-7610.1989.tb00274.x

Teitelbaum, P., Teitelbaum, O., Nye, J., Fryman, J., & Maurer, R. G. (1998). Movement analysis in infancy may be useful for early diagnosis of autism. *Proceedings of The National Academy of Sciences*, *95*(23), 13982-13987. doi:10.1073/pnas.95.23.13982

Teunisse, J., & Gelder, B. D. (2001). Impaired categorical perception of facial expressions in high-functioning adolescents with autism. *Child Neuropsychology*, *7*(1), 1-14. doi:10.1076/chin.7.1.1.3150

Travis, L. L., & Sigman, M. (1998). Social deficits and interpersonal relationships in autism. *Mental Retardation and Developmental Disabilities Research Reviews*, *4*(2), 65-72. doi:10.1002/(SICI)1098-2779(1998)4:23.0.CO;2-W

Uljarevic, M., & Hamilton, A. (2013). Recognition of emotions in autism: a formal meta-analysis. *Journal of Autism and Developmental Disorders*, *43*(7), 1517-1526. doi:10.1007/s10803-012-1695-5

Van de Riet, W., Grezes, J., & De Gelder, B. (2009). Specific and common brain regions involved in the perception of faces and bodies and the representation of their emotional expressions. *Social Neuroscience*, *4*(2), 101-120. doi:10.1080/17470910701865367

Van den Stock, J., Jong, S. J., Hodiamont, P. P., & de Gelder, B. (2011). Perceiving emotions from bodily expressions and multisensory integration of emotion cues in schizophrenia. *Social Neuroscience*, *6*(5-6), 537-547. doi:10.1080/17470919.2011.568790

Van den Stock, J., Righart, R., & de Gelder, B. (2007). Body Expressions Influence Recognition of Emotions in the Face and Voice. *Emotion*, *7*, 487-494.

Vicari, S., Reilly, J. S., Pasqualetti, P., Vizzotto, A., & Caltagirone, C. (2007). Recognition of facial expressions of emotions in school-age children: the intersection of perceptual and semantic categories. *Acta Paediatrica*, *89*(7), 836-845. doi:10.1111/j.1651-2227.2000.tb00392.x

Wallbott, H. G. (1998). Bodily expression of emotion. *European Journal of Social Psychology*, *28*, 879-896. doi:10.1002/(SICI)1099-0992(1998110)28:63.0.CO;2-W

Zachor, D. A., Ilanit, T., & Itzchak, E. B. (2010). Autism severity and motor abilities correlates of imitation situations in children with autism spectrum disorders. *Research in Autism Spectrum Disorders*, *4*(3), 438-443. doi:10.1016/j.rasd.2009.10.016

Zwaigenbaum, L., Bryson, S., Rogers, T., Roberts, W., Brian, J., & Szatmari, P. (2005). Behavioral manifestations of autism in the first year of life. *International Journal of Developmental Neuroscience*, *23*(2-3), 143-152. doi:10.1016/j.ijdevneu.2004.05.001