BODILY EMOTION RECOGNITION DIFFERENCES BETWEEN AUTISM SPECTRUM DISORDER AND TYPICAL DEVELOPMENT

A Dissertation

by

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ABSTRACT

Recognizing others' emotional states from their nonverbal expressions has been widely studied in typically developing (TD) and clinical populations, such as Autism Spectrum Disorder (ASD), and is thought to underlie several components of adaptive social-emotional functioning. Findings show TD humans develop and refine this ability throughout childhood and suggest a female recognition advantage in many cases. Moreover, different emotions are associated with the unique posturing of specific features and regions. Guided by this, eye-tracking has allowed researchers to examine how observers visually process this information during emotion recognition tasks. A lack of attention to these features is associated with poorer recognition. Importantly, however, the majority of research in these areas has focused on faces.

Increasing amounts of research have shown that TD individuals can accurately recognize emotions from bodily expressions, and similarly view core areas and postural information associated with specific emotions. Yet, the extant literature is quite limited relative to faces. Motivated by this, the current study sought to examine emotion expression processing from the face and body and how this relates to social-emotional functioning. During a recognition task, 41 TD children (7-11-years old) viewed expressions of basic emotions from the face and body while their eye movements were recorded. Recognition performance and gaze behavior were compared within and across faces and bodies. In addition, the relationships between recognition performance and gaze and between recognition performance and ratings of participants' social-emotional functioning were explored.

Results indicated differential accuracy performance for certain emotions within each modality, as well as an advantage for recognition of happy and neutral emotions from faces compared to bodies. In addition, participants tended to focus their visual attention on core face and body areas associated with accurate recognition. Sex and age effects also emerged modulating these findings. There were significant relationships between recognition and both eye gaze and social-emotional functioning. Findings and the lack thereof were discussed in relation to previous literature, as well as the implications of how this study can inform future research, particularly in the ASD community.

DEDICATION

To my parents, Lane and Susan, whose love and support made me believe I could do this in the first place; to my wonderful wife, Julia, whose love and support is the main reason I am actually finishing this; and to my daughter, Lanie, who made it all even more worth it.

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TABLE OF CONTENTS

LIST OF FIGURES

Figure 14. Differences in number of fixations across AOIs while viewing facial expressions of emotion 109

LIST OF TABLES

CHAPTER I

INTRODUCTION

Preface

This was an untraditional project to complete, which was evident in writing it, and should likely be evident when reading it. Unsurprisingly, this stemmed mainly from the unpredictability, changes, and subsequent stress and fear of the recent year due to the COVID-19 pandemic. Given the widespread social distancing and hiatus of in-person experimental research, the originally proposed study was shut down before any significant data collection was completed. To maintain the theme of the originally planned study as much as possible, data from a previous pilot study was analyzed. This pilot study, for example, did not include individuals with Autism Spectrum Disorder (ASD) but instead consisted of typically developing (TD) children. As such, information for the originally planned study (i.e., introduction, literature review, and methodology) was discussed in this manuscript followed by data analysis based on the pilot study. Where relevant, changes to the originally planned study were noted.

Introduction to the Originally Planned Study

Autism Spectrum Disorder (ASD) represents a set of behaviors present in one in every 59 children, affecting males at a rate four times higher than females (Center for Disease Control and Prevention; CDC, 2018). At this time, ASD is diagnosed based on a set of behavioral criteria, which are manifested by two years of age (CDC, 2018). 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 individuals 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 phenotype, social impairments are a prominent feature of ASD and have been noted since Kanner's (1943) original case study. The ability to recognize others' emotions is a cornerstone of affective and social function. Indeed, research has argued that accurate emotion expression recognition influences social adjustment and interpersonal behavior, learning and academic success, and even business-related outcomes (Elfenbein, Foo, White, Tan, & Aik, 2007; Izard et al., 2001; Garner, 2010; Leppänen & Hietanen, 2001). Salovey and Mayer (1990) argued that the ability to perceive emotions subserves emotional intelligence, and that emotions make social and personal communication more rewarding. Thus, impairments in emotional intelligence in ASD, might diminish rewards associated with social and personal communication, reducing social interactions and leading to further reduced social competency.

Emotion expression recognition in ASD has been a widely studied line of research for years, comprising several accuracy- and performance-based paradigms, as well as the increasing utilization of technology to examine subtle behavioral (e.g., eye-tracking) and neurobiological (e.g., electroencephalogram) differences (Harms, Martin,

& Wallace, 2010; Uljarevic & Hamilton, 2013). Despite the amount of research available, there is no single, clear, or consistent answer as to whether individuals with ASD have inherently atypical emotion expression perception (Harms et al., 2010; Uljarevic & Hamilton, 2013). To further complicate matters, the vast majority of this research focuses on facial emotional expressions, although evidence has begun to indicate that emotions are not only communicated by bodies but that naturalistic, accurate emotion perception stems from both faces and bodies together (de Gelder, 2009). Thus, little is known about whether individuals with ASD perceive emotions from bodies or combined face-body expression accurately or in a typical manner compared to TD peers. Understanding this may provide not only a fuller understanding of emotion expression perception in this population, but it may also inform better social skill interventions for people with ASD.

Originally Planned Study Purpose

To this end, the original study sought to examine recognition and processing of nonverbal emotional expressions from faces and bodies, both combined and in isolation, in individuals with ASD compared to TD individuals. As such, the original study paradigm consisted of emotion recognition tasks with concurrent eye-tracking of participants' gaze behavior, which will provide information about how emotions or viewed compared to TD controls.

Research Questions for Originally Planned Study

Based on the literature, the original study sought to examine the following questions remain regarding BER specifically and multimodal emotion recognition more broadly:

Do individuals with ASD show a relative strength for BER compared to FER in terms of accuracy? It was hypothesized that ASD FER performance would remain higher, possibly due to social skills training that has historically focused on faces (e.g., Neumann et al., 2006; Spezio et al., 2007).

1. Are recognition benefits for congruent, compound stimuli found in TD individuals also present in ASD, either in general or for specific emotions, compared to both ASD FER and BER performance? It was hypothesized that ASD participants would better emotion recognition accuracy performance for compound stimuli as compared to their own FER or BER performance.
2. Does ASD recognition performance change relative to TD when viewing compound stimuli? It was hypothesized that ASD performance would remain below TD when comparing recognition for compound stimuli, but would improve when compared to TD FER and BER alone.
3. Do TD college students scan and process bodies in a distinct and strategic manner analogous to faces and do these patterns change when viewing compound stimuli? Given the limited literature, no clear hypothesis was made, but it was predicted that changes would be seen for some but not all emotions.

4. Do ASD college students show a similar gaze relative to TD controls when viewing bodies-alone or face-body compounds? It was hypothesized that differences would be minimized in body-only but not in face-body compounds.

5. Does ASD gaze behavior for certain body areas predict their emotion recognition performance in bodies alone and in compound expressions? Again, no clear hypothesis was made due to the exploratory nature of this question.

Overview of the Pilot Study

Following Ekman and Friesen's (1971) research positing universal recognition of basic emotion expressions, facial expressions have comprised the vast majority of emotion recognition research (de Gelder, 2009). Nevertheless, research has shown that bodily expressions provide viable, accurate, and important emotion information for proper social-emotional functioning similar to faces (de Gelder, 2009), and share several characteristics associated with facial expressions. For instance, humans begin to process emotions from both faces and bodies within the first year of life (e.g., Soken & Pick, 1999; Zieber et al., 2014), encode and decode both facial and bodily emotions via distinct posturing and movements (e.g., Calvo et al., 2010; Tanaka et al., 2012; Wallbott, 1998; Witkower & Tracy, 2019), and are thought to universally recognize basic emotions from either modality (e.g., Ekman & Friesen, 1971; Sogon and Masutani, 1989). Furthermore, researchers have suggested that TD humans visually process both faces and bodies similarly, likely configurally (Atkinson et al., 2007; Maurer et al., 2002; Reeds et al., 2012). Despite these similarities, questions remain in several areas.

One such area relates to moderating effects on accurate emotion recognition, such as modality (i.e., face versus body advantage), age, and sex. For instance, there is some research to suggest certain emotions may be better expressed from one modality over another in adults (Actis-Grosso et al., 2015; Avezier et al.2012; Coulson, 2004). In addition, emotion recognition development has been examined extensively in facial expression research but noticeably less for bodies. Developmental research in TD individuals has consistently found patterns in which facial emotion recognition and processing emerge across early childhood and improve into adolescence and beyond for specific emotions (Herba et al., 2006; Ludemann & Nelson, 1988; Vicari et al., 2000). Sex has also shown to affect emotion recognition performance in children and adults during FER tasks. Yet, literature is lacking for body expressions.

Beyond emotion recognition performance, researchers have examined possible underlying mechanisms of emotion expression processing. Technological advancements, such as eye-tracking, have allowed researchers to explore how individuals visually scan emotional expressions and how their gaze behavior relates to emotion recognition and age and sex effects (e.g., Hall et al. 2010; Karayanidis et al., 2009; Pollux et al., 2019*;* Schurgin et al., 2014). This area of research also has focused largely on adult processing of facial emotion relative to bodies generally, as well as children's eye-tracking. While limited eye-tracking literature incorporates body expressions and shows similar pattern of results, it is limited overall and focuses largely on adults. As such, examining eye gaze during both BER and FER tasks of children across sex and ages ranges can provide new understanding how humans process emotional expressions.

Beyond simple nonverbal communication signaling, some scholars conceptualize emotion recognition to underly other aspects of emotional intelligence, such as emotion knowledge, regulation and action and, in turn, broader social-emotional functioning (e.g., social skills, peer acceptance, psychopathology; Izard et al., 2011; Salovey & Mayer, 1990). Indeed, children with poor emotion recognition abilities have shown to be less liked by peers (McClure, 2000) and show increased internalizing and externalizing behaviors (Castro et al., 2018; Schultz et al., 2004). However, this is often examined in young children using FER tasks, leaving questions about the relation between BER skills and social-emotional functioning.

Pilot Study Purpose

This pilot study ultimately served two purposes. First, as the name suggests, it acted as a pilot for the originally planned study, providing valuable information and experience to make adjustments and improvements. Second, it offered an opportunity to expand the research surrounding bodily emotion processing in the TD population, which also served to strengthen comparisons in the originally planned study.

Based on the literature, there is a dearth of literature regarding the processing of body expressions relative to faces. In addition, there also appears to be a distinct gap in the research focusing on the eye movements during emotional body expression processing relative to faces in general. This gap widens when considering possible developmental and sex effects. Despite the historical focus on faces, there are still holes in the FER literature, such as developmental changes in eye movements during facial emotion processing and possible differences due to sex, which are found elsewhere in the FER performance domain. Lastly, more research is needed to explore BER and its relationship with broader social-emotional functioning. Based on the available research in this area, this study set out to answer the following questions:

1. Do older children show differences in emotion recognition accuracy within bodily and facial emotional expressions? Given the limited research relating to BER, no hypothesis was made about specific recognition performance differences within bodily emotions. Nevertheless, it was hypothesized that general recognition differences would emerge. Regarding faces, it was hypothesized that happiness would be most recognized.
2. Do older children show recognition differences for certain emotions across modalities? Again, research is limited in this area as well, it was hypothesized that better FER performance would emerge for some but not all emotions, while no BER advantage would be seen.
3. Do children show a similar pattern gaze patterns for emotional bodies and faces that are highlighted in the literature (i.e., eyes, nose, mouth, upper body areas)? It was hypothesized that children would show similar patterns as those found in the adult literature with more and longer fixations towards core facial features and upper body areas.
4. Are there age and sex effects within and across BER and FER tasks for children in the age range of participants in the pilot study (i.e., 7-11 years)? It was

hypothesized that both would affect performance and gaze behavior, with older participants and females showing better recognition and more and longer fixations to core areas of faces and bodies.

5. Are children's gaze patterns related to their emotion recognition performance? It was hypothesized that gaze behavior directed at core face and body areas would be positively related to emotion recognition accuracy.
6. Does BER performances for basic emotions in this age group correlate with parent- and self-reported ratings of social-emotional functioning? This was largely exploratory, but it was hypothesized that significant associations would be found between levels of BER and ratings of social-emotional functioning.

CHAPTER II

LITERATURE REVIEW

Original Study

Theories of ASD

Considering the complexity and broad nature of behavioral excesses and deficits associated with ASD, it is unsurprising that several theories have been put forth in hopes of explaining its underlying cause. These theories have catalyzed several lines of research that have helped elucidate and inform many of the myriad aspects of ASD, development of typically developing (TD) individuals, and interventions; however, these theories are not without shortcomings. Moreover, it has become apparent that a single explanatory cause of ASD is shortsighted, if not impossible (Happé & Ronald, 2008). Rather, ASD behaviors may stem from several atypical underlying mechanisms, working simultaneously at varying levels. In this section, some of these theories are reviewed briefly, beginning with two of the most prevailing theories, Theory of Mind and Weak Central Coherence, as well as a newer theory that has gained some traction in the field of ASD, Social Motivation Theory.

Theory of Mind. Theory of Mind (ToM) refers to a social-cognitive mechanism underlying the ability to infer mental states, such as thoughts, beliefs, or emotions, to oneself and others (Carlson, Koenig, & Harms, 2013; Goldman, 2012; Wimmer & Perner, 1983). ToM skills begin to emerge around two-years-old as TD children begin to understand that others possess mental states (e.g., emotions, wants; Carlson et al., 2013). As children age, their conceptual understanding of mental states matures, allowing children to understand that people can hold knowledge and beliefs different from their own (Carlson et al., 2013). This level of ToM typically presents around four-to-five-years-old and has been traditionally assessed via a False-Belief task, wherein a child who possesses mature ToM is able to understand that others may hold false beliefs and use that understanding to predict their behavior (Carlson et al., 2013; Miller & Marcovitch, 2012; Wimmer & Perner, 1983). In a classic false-belief paradigm, a child observes an actor place an object in one spot then leave the vicinity, whereupon a second actor enters and moves the object before the first actor reenters (Wimmer & Perner, 1983). The child then must choose where the first actor will search for the item. Picking the object's original location is thought to imply a more developed ToM, signaling that these children can mentally represent a difference in their own knowledge (i.e., true belief about the location) and that of the first actor (i.e., false belief about location), which will guide behavior (Wimmer & Perner, 1983).

As ToM suggests an ability to understand that others can have different mental states (e.g., emotions, thoughts) that affect subsequent behavior, it is thought to play an important role in social functioning (Happé & Frith, 2014). Indeed, to have successful interpersonal skills and interactions, one must be able to infer and predict what others are thinking or feeling constantly and consistently. Thus, it stands to reason that ToM deficits are often theorized to underlie core social-communication impairments in ASD (Baron-Cohen, 2001; Happé & Frith, 2014). In a seminal study, Baron-Cohen, Leslie, and Frith (1985) found that children with ASD performed worse than TD and Down's Syndrome control groups on a False-Belief task, despite higher intellectual functioning.

This early finding of a ToM weakness has been replicated in later False-Belief tasks (e.g., Girli & Tekin, 2010) and extended to several other paradigms that require various levels of ToM, such as attributing mental states from eyes alone (Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997; Beaumont & Newcombe, 2006; Holt et al., 2014; Pino et al., 2017), correctly sequencing picture-based stories (Baron-Cohen, Leslie, & Frith, 1986; Pino et al., 2017), inferring mental states from static or dynamic social scenes (Beaumont & Newcombe, 2006), and identifying implied meaning from nonliteral language (e.g., jokes, lies, metaphors; Happé, 1993, 1994; Murray et al., 2017). Importantly, results have highlighted ToM deficits related to social impairments in understanding others' knowledge, intention, beliefs, and emotions.

Despite the large literature base supporting ToM deficits in ASD, some have challenged the central role it has played in explaining ASD. Namely, ToM alone cannot explain non-social symptoms (i.e., restricted and repetitive behaviors and interests) or particular strengths (e.g., visuospatial skills; Frith & Happé, 1994; Tager-Flusberg, 2007). Moreover, ToM impairment may be neither specific to nor universal in ASD, as originally conceived (Tager-Flusberg, 2007). Studies have shown a small proportion of ASD participants to pass ToM tasks (e.g., Baron-Cohen et al., 1985; Brunsdon & Happé, 2014; Happé, 1994), while researchers have pointed out that other clinical populations often show ToM impairments (e.g., blindness, schizophrenia; Baron-Cohen, 2001; Hughes & Leekam, 2004; Tager-Flusberg, 2007). Nevertheless, Happé (2015) noted that ToM provided an important conceptualization of many social-communicative issues in ASD, as well as facilitated several lines of research that continue to inform the field.

Weak Central Coherence. In an attempt to explain nonsocial characteristics of ASD, a perceptual-cognitive theory was posited—Weak Central Coherence (WCC; Frith & Happé, 1994; Happé, 1999; Happé & Frith, 2006). Central coherence reflects a cognitive style in which TD individuals tend to process information within its broader context, integrating bottom-up and top-down processes to create a coherent whole. In other words, TD populations may be biased towards processing stimuli globally, rather than locally, in a gestalt fashion, while the reverse may be true for ASD individuals. Importantly, WCC does not necessarily imply an impairment, as some abilities may benefit from a featural or local processing tendency (e.g., visual-spatial skills, discrimination ability, perfect pitch).Though WCC may hinder performance on tasks that call for a global processing style (Frith & Happé, 1994; Happé, 1999; Happé & Frith, 2006), such as a lack of subitizing (Jarrold & Russell, 1997), higher motion coherence thresholds (Milne et al., 2002), face and emotion expression processing differences (Atkinson, 2009; Behrmann et al., 2006), and deficits integrating contextual information to make correct inferences (Jolliffe & Baron-Cohen, 1999; López & Leekam, 2003).

As with ToM, WCC has its detractors, likewise stemming from questions of its universality within and specificity to ASD. For instance, Jarrold and Russell (1997) found that not all ASD individuals showed local versus global bias when counting groups of stimuli. Likewise, López and colleagues (2008) showed a possible disconnect within the central coherence mechanism as shown through differential performance levels on semantic coherence and perceptual coherence tasks within the ASD group, indicating a possible divided WCC construct with heterogenous performance profiles.

Results from López and Leekam (2003) indicated a lack of WCC effects when integrating sets of visual and verbal semantic information; however, the level and complexity of the information was relatively simple. Together, these results suggest that the type of and level of weakness in central coherence may be variable in ASD. Additionally, WCC can be found in other clinical groups, such as schizophrenia (Happé & Frith, 2006). Despite these challenges, WCC has provided further direction and explanation for some of the characteristics in ASD, by directly exploring many nonsocial features but also some of the social atypicality, albeit more indirectly.

Social Motivation Theory. A relatively newer theory has also gained traction to explain some of the ASD symptomatology, pointing to motivational differences in ASD. The Social Motivation Theory (SMT) hypothesizes that individuals with ASD inherently find social stimuli less rewarding, unlike their TD peers, creating a lack of motivation to seek out, attend to, and share in social events (Chevalier et al., 2012). Without this motivation for social input, children with ASD are subsequently deprived of important early social experiences and learning, resulting in downstream social skill deficits (Chevallier et al., 2012). Indeed, findings from observational, behavioral, and neuroscientific studies have converged to show reduced social motivation in ASD.

Research shows that TD individuals preferentially attend to social stimuli (Fletcher-Watson et al., 2008; Gliga et al., 2009; Shepherd, 2010; Vouloumanos et al., 2010), which may be related to later social cognition (Wellman et al., 2004) and find it inherently rewarding (Hayden et al., 2007).

Conversely, research has found an absent or blunted response in many of these behaviors or effects seen in TD individuals. For example, results have shown a lack of preference for human speech sounds (Klin, 1991), deficits in social orienting (Dawson et al., 2004), and reduced visual gaze for social versus nonsocial stimuli (Chevallier et al., 2015; Klin et al., 2002; Nakano et al., 2010). It is possible that low reward value of social variables underlies reduced social motivation. Children with ASD choose social rewards less often than TD peers (Lin et al., 2012; Ruta et al., 2017; Wang et al., 2018). Therefore, it is plausible that a lack of inherent reward in social domains in ASD may reduce the proclivity for social attention typically found in TD populations. In turn, this may alter the trajectory of social-communicative skill development due to lack of experiential learning (Chevallier et al., 2012).

Similar to ToM and WCC, SMT may only explain some of the deficits and characteristics in ASD. As its name suggests, SMT tends to account for social differences rather than the full range of social and nonsocial aspects (Chevallier et al., 2012). However, recent research has suggested a broad atypical reward system in ASD that may explain both social motivation differences and increased motivation for RRBIs (Kohls et al., 2018). Moreover, reduced social motivation is also found in other disorders (e.g., Schizophrenia; Chevallier et al., 2012). Additionally, Garman and colleagues (2016) found a range of social motivation preferences in ASD as measured by social persistence scales, and also suggested that social motivation may not be a unitary construct.

Summary of Theories of ASD. From the literature reviewed here, it is apparent that no single theory may explain all the characteristics associated with ASD. Rather, there is growing thought that these characteristics stem from largely independent bases, affecting ASD individuals at variable levels (Happé & Ronald, 2008). This may help explain often uneven performances and outcomes in studies of the putative mechanisms underlying deficits in ASD (e.g., Baron-Cohen et al., 1985; Garman et al., 2016; Jarrold & Russell, 1997) and the heterogeneity often visible within ASD (e.g., Borden & Ollendick, 1994). Indeed, recent research has shown that while ASD may show higher rates of atypical cognition (e.g., ToM, WCC) compared to TD populations more generally, this is not a universal feature (Brunsdon et al., 2015). Therefore, it may be more appropriate to assume that these theories work in tandem to produce the broader ASD phenotype (Happé & Ronald, 2008). These theories are not mutually exclusive. Indeed, the theories reviewed here—ToM, WCC, and SMT—posit atypical ASD functioning from several cognitive areas (i.e., social, perceptual, motivational), informing ASD behavior alone, as well as interactively. One area that may show impairments due either to these theories alone or in concert is emotion expression recognition. In other words, these theories may overlap at times, while also providing unique etiological explanations for ASD behaviors. Importantly, emotion recognition is an often-studied area in ASD in which SMT, WCC, and ToM may provide unique and interactive answers for inconsistent performance in this population.

Emotion recognition is an important skill that underlies broader social-emotional behavior, and poor emotion recognition may prevent or impair accurate and effective social-emotional functioning in ASD. Furthermore, emotion recognition is an area that exemplifies how multiple theories can overlap to better explain behavior and functioning. For instance, ToM deficits may suggest that emotion recognition impairments are due to an inability to represent their emotional mental state, while SMT may suggest that reduced motivation to attend to socioemotional cues leads to inexperience decoding others' expressions accurately. A WCC style may predispose to featural rather than configural expression processing, leading to inaccurate decoding. Or, possibly, they interact in some fashion, such as early social motivation deficits prohibit the experiences needed to process expression configurally and attributing an emotional mental state. By the same token, relatively typical or intact functioning in one, or all, of these areas may lead to variable findings of emotion recognition skills in some individuals with ASD in certain situations. Considering Brunsdon and colleagues (2015) indicated that atypical cognition is more widespread in ASD compared to TD populations, emotion recognition, as well as many other social skills, may be impaired in several but not all ASD individuals, which seems to be the case (e.g., Uljarevic & Hamilton, 2013), and is reviewed more fully in the next section.

Emotion Recognition in ASD

Emotion recognition has been a widely researched area in ASD, stemming mostly from studies of facial expression recognition. However, there has been no definitive consensus regarding the presence of widespread, universal emotion recognition impairments in ASD, although several variables related to both methodology and participant characteristics may factor into contrasting findings. Certain technologies, such as eye-trackers, have been increasingly used to help determine the presence of differences in a more perceptual manner, building on findings of possible processing style differences in ASD. Moreover, the TD literature has seen increased examination, with both traditional recognition and eye-tracking paradigms, of body and combined face and body emotional expressions, providing a fuller and more authentic understanding of human emotion expression recognition. This trend has begun to spread to the ASD field as well. These areas of emotion recognition in ASD are discussed more in-depth below, beginning with facial emotion recognition (FER) in ASD.

Facial Emotion Recognition in ASD. Several studies have examined the possible presence of FER deficits in ASD with mixed results. While several findings have pointed to an emotion recognition impairment in this population, many results have shown no differences between ASD and TD individuals' emotion recognition skills (Uljarevic & Hamilton, 2013). When deficits have been found, they have arisen across different age groups, tasks, emotions, stimuli, and control groups. For instance, labelling tasks are one of the most common experimental paradigms used to examine FER performance in ASD (Uljarevic & Hamilton, 2013). During emotion labelling tasks, participants are typically presented with an emotional expression before subsequently choosing a verbal (e.g., Castelli, 2005) or written (e.g., Bours et al., 2018) label.

When used, studies with labelling tasks have found FER deficits in ASD participants, ranging from children to adults, across all basic emotions (i.e., happiness, sadness, anger, fear, surprise, disgust; Ekman & Friesen, 1976) presented in the study. For example, Tantam and colleagues (1989) presented participants images of either objects (e.g., radiator, ice-cream lamp-post, knife) or the six basic facial expressions and were given word lists to describe either the objects (e.g., hot, cold, sharp) or the facial emotions (e.g., happy, sad, scared). The authors found that children with ASD were significantly less accurate when labeling static facial expressions of basic emotions compared to TD controls, but not the objects, indicating emotion-specific impairments. Subsequent studies have shown similarly poor FER performance in adolescents with ASD during labeling of facial emotion images (Bolte & Poustka, 2003; Bours et al., 2018; Brosnan et al., 2015). Additionally, when instructed to label facial expressions as either emotional (i.e., happy, angry, fearful) or non-emotional (i.e., neutral), TD adolescents performed significantly better, as well as marginally faster, than the ASD group, underscoring reduced emotion perception in this group (Dalton et al., 2005). Similar results have also been found in adults with ASD relative to TD adults on tasks of static, basic facial emotion expression labeling in several studies (Bolte & Poustka, 2003; Macdonald et al., 1989; Sawyer et al., 2012; Walsh et al., 2016).

Additional studies have found different FER performance for specific emotions during labeling tasks. Adolescents in McCabe et al. (2013) showed poorer FER for disgusted expressions compared to TD controls. Pelphrey and colleagues (2002) found significantly lower accuracy for fear recognition in ASD compared to TD adults; however, the ASD group performed worse across all other basic emotions tested. Likewise, Philip and colleagues (2010) found that adults with ASD were less accurate when labelling static sad, angry, and fearful facial expressions, while adults in Corden et al.se (2008) showed poorer fear and sadness FER performance compared to TD controls.

Compared to TD groups, individuals with ASD appear to be impaired when attempting to label facial emotions.

In an effort to demonstrate emotion recognition skills as uniquely impaired in ASD, other studies have compared FER labeling performance to other clinical groups with emotion recognition deficits. For instance, Bolte and Poustka (2003) found reduced FER accuracy for static, basic emotions in adolescents and young adults with ASD compared to a control group with schizophrenia and healthy controls, who showed no significant differences. While labeling tasks have demonstrated FER impairments across several studies, other tasks have also been used to explore FER in ASD.

Indeed, expression matching and sorting tasks of basic emotions have shown FER deficits in ASD. In facial emotion expression matching paradigms, the participant is typically shown a target emotion (e.g., sadness) and then instructed to match that expression to a similar expression depicted by a different model (e.g., Celani et al., 1999; Philip et al., 2010). During facial emotion sorting tasks, the participant is tasked with sorting several images of faces according to according to a variable that differs in its presence or absence across the facial stimuli (e.g., facial emotion, type of hat, facial hair; Weeks & Hobson, 1987; Begeer et al., 2006). Compared to TD controls, Philip and colleagues (2010) found that adults with ASD were less accurate when matching emotional facial expressions, driven by a large difference in sad expressions. When given happy and sad facial expressions, children with ASD were found to be less accurate relative to both TD controls and children with Down’s Syndrome (Celani et al., 1999). In the same study, children and adolescents with ASD were less able to accurately sort based on emotional expression (i.e., happy or neutral faces) compared to TD and clinical controls (Celani et al., 1999). Similarly, Weeks and Hobson (1987) presented child to adult-aged participants with a series of photographs that differed either in facial emotion (i.e., happy or neutral), sex of model (i.e., male or female), or type of hat (i.e., woolen or floppy). Results showed that TD participants overwhelmingly sorted by facial expression; however, ASD participants generally sorted by hat, suggesting a lack of emotional salience for ASD individuals. Building upon Weeks and Hobson’s (1987) study, Begeer et al. (2006) found similar results when faces differed in emotional expression (i.e., happy or angry) and/or the presence or absence of a mustache or glasses. Again, children with ASD spontaneously sorted stimuli by non-emotional features more so than TD controls. Consistent with results from labeling studies, matching and sorting tasks suggesting that FER performance is uniquely and pervasively impaired in ASD.

Despite these multiple examples of FER deficits in ASD, contrasting literature exists that calls to question the presence of FER impairments by showing similar performance between groups (e.g., Castelli, 2005; Falkmer et al., 2011; Høyland et al., 2017; Neumann et al., 2006). Nevertheless, researchers have begun to point to participant (e.g., age, emotional development, functional level), task (e.g., complexity, timed versus untimed displays), and stimuli (e.g., morphed versus prototypical, static versus dynamic) variables as possible reasons for equivocal findings (Harms et al., 2010; Uljarevic & Hamilton, 2013). These important factors and their possible effects on findings in the FER literature are reviewed further in the next section.

Potential Variables Affecting Emotion Recognition Findings. Participant-specific characteristics such as age, functional level, and current emotional development, each alone or through interactive effects, may play a role in the unclear state of affairs regarding the presence or absence of emotion recognition deficits in ASD. For example, research suggests that TD emotion recognition skills develop in a protracted manner, beginning with emotion discrimination in infancy (Farroni et al., 2007; LaBarbera et al., 1976; Peltola et al., 2009; Soken & Pick, 1999) and continuing into adulthood (Herba et al., 2006; Gao & Maurer, 2010; Thomas et al., 2007; Vicari et al., 2000),with happiness being the first emotion recognized followed by sadness then anger, fear, and disgust (Durand et al. , 2007; Vicari et al., 2000). A failure to find FER differences may reflect the age and, thus, potentially underdeveloped skills in TD controls rather than a lack of impairments (Harms et al., 2010).

For example, researchers who have examined FER across age groups have found variable FER differences across ASD and control groups. Falkmer and colleagues examined facial emotion expression (i.e., happy, angry, surprise) matching in children (Leung et al., 2013) and adults (Falkmer, et al., 2011) with ASD compared to TD controls, finding similar child but reduced adult ASD accuracy. Similarly, Rump et al.(2009) found labelling differences for dynamic displays of basic emotions in ASD adults but not older children (i.e., 8-12 years) and adolescents with ASD. Moreover, within group comparisons have supported the notion that TD emotion recognition matures across the lifespan with significantly better accuracy in adults compared to children; however, this trend was not seen in the ASD group. Specifically, there was no significant difference between ASD adult and child FER (Rump et al., 2009). Together, these results support that possibility that similar group FER performances in certain studies may be due to variable emotion recognition development within groups.

Beyond age and emotional development, other participant variables are important to consider. Cognitive functioning has been cited as a possible mediating factor for similar FER group findings (Harms et al., 2010; Trevisan & Birmingham, 2016). In their review of FER research, Harms and colleagues (2010) noted that verbal intelligence (VIQ) may facilitate the use of learned, explicit strategies to compensate for poorer automatic FER, especially as ASD recruitment may draw from special schools or social skills training programs (Neumann et al., 2006; Ozonoff et al., 1990; Spezio et al., 2007a). Consistent with the notion of intelligence effects, Ozonoff et al. (1990) found FER differences when ASD and TD participants were matched for nonverbal intelligence (NVIQ) but not when matched for VIQ. Similarly, Castelli (2005) showed no facial emotion labelling or matching differences in ASD and TD children when matched for VIQ but not age, possibly implicating both increased cognitive capabilities in ASD, as well as lower emotional development in TD controls who were younger. More recent studies have shown that intelligence was related to recognition of anger (Enticott et al., 2014) and disgust (McCabe et al., 2013). Thus, a lack of differences may be due to differences in age and emotional development, as well as the cognitive functioning and learning of the ASD participants.

Similarly, intragroup variability has also been shown to be related to FER performance outcomes. Indeed, ASD is a very heterogeneous disorder, allowing for a wide range of etiologies, clinical presentations, and severities (Ameis, 2017; Georgiades et al., 2013; Lenroot & Yeung, 2013; Masi et al., 2017; Rice et al., 2012). Several studies have shown a relationship between performance and severity. For instance, Teunisse and de Gelder (2001) initially found significant ASD and TD adolescent group differences during labeling of angry, sad, happy, and fearful facial expressions; however, when the authors accounted for social intelligence, different patterns emerged, indicating differences for the low social intelligence ASD subgroup only. Similarly, Philip and colleagues (2010) also noted ASD subgroup presence in their study. Using the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000), the authors indicated two subgroups, falling either below or above the ADOS diagnostic cutoff score. Although TD controls performed better than both, the less severe subgroup showed higher accuracy. Additionally, increased social problem severity in ASD participants was shown to be associated with increased reaction time on a facial emotion discrimination task for younger participants (Høyland et al., 2017), as well as poorer anger recognition (Bal et al., 2010) and reduced FER performance for human compared to animated faces (Brosnan et al., 2015). Thus, it appears that multiple participants characteristics, such as age, development, functioning, and intragroup heterogeneity may affect study outcomes.

It is important to consider that participant characteristics alone may not completely explain inconsistent FER behavioral findings. Indeed, methodological characteristics, such as particular stimuli and task demands, must also be considered, and they may interact with participant qualities to affect study outcomes. For instance, in certain studies high-functioning ASD participants may perform as well as controls when experimental stimuli include prototypical, static displays of certain basic emotions due to explicit instruction with similar materials (e.g., Neumann et al., 2006; Spezio et al., 2007a). Additionally, it has been suggested that task instruction may affect performance. Weeks and Hobson (1987) and Begeer and colleagues (2006) showed that explicitly instructing ASD participants to sort images of faces by emotional expression erased any group differences. This suggests that FER may not necessarily be impaired in some individuals with ASD, but it may not be automatic or spontaneous as in TD individuals. It is possible, then, that explicitly prompting certain behaviors during emotion processing tasks may facilitate explicit, compensatory FER strategies.

The specific stimuli used and their presentation are two possible confounds in the experimental literature. Facial emotion stimuli often comprise static, prototypical images of one or more basic emotions displayed either without or with varying time frames (Black et al., 2017; Harms et al., 2010; Uljarevic & Hamilton, 2013), which may facilitate compensatory strategies and, thus, typical performance for some participants. Consistent with this notion, some studies have found similar performance for static expressions of basic emotions (Baron-Cohen et al., 1997; Bekele et al., 2013; Castelli, 2005; Leung et al., 2013; Neumann et al., 2006; Rump et al., 2009; Rutherford & Towns, 2008; Sasson et al., 2007; Spezio et al., 2007a) with no time limit (Baron-Cohen et al., 1997; Castelli, 2005; Rump et al., 2009; Sasson et al., 2007) or with extended time limits (e.g., 10s; Leung et al., 2013; Neumann et al., 2006; Spezio et al., 2007a), possibly supporting the use of compensatory strategies, especially when given ample time.

When researchers have taken these potential confounds into consideration, group differences have emerged. For instance, while Rump and colleagues (2009) showed similar performance with prototypical, untimed static expressions of basic emotions but significantly poorer FER for surprised, disgusted, angry, and fearful dynamic, rapid (500ms) facial expression stimuli. Likewise, other studies have shown FER deficits across several facial emotions when using short presentations of dynamic stimuli, including significant impairments during short presentations for anger, fear, sadness, and happiness (250ms; Walsh et al., 2016), sadness, disgust, and anger (1s; Enticott et al., 2014), and for sadness, disgust, and surprise (1-2s; Evers et al., 2015); moderate presentations for fear, happiness, disgust, and surprise (4s; Han et al.2015) and excited, kind, sad, surprised, happy, and proud (5s; Brosnan et al., 2015); as well as during extended presentations for anger (15-33s; Bal et al., 2010); suggesting that manipulating the presentation time and motion of facial expressions may unearth FER differences, at least for specific emotions.

Additionally, recognition performance differences have emerged when increasing the ambiguity or complexity of the stimuli in some way. Some researchers have utilized morphed stimuli of basic emotions, in which either a single emotion is presented at different intensity levels, demonstrating impaired anger, disgust, happiness, and sadness recognition (Griffiths et al., 2017), or two emotions are combined at different ratios to create a continuum, finding deficits in anger and fear (Philip et al., 2010; Wang & Adolphs, 2017) and sad expressions (Philip et al., 2010). Additionally, brief presentation times, 300ms and 1s, were used in Griffiths et al. (2017) and Wang and Adolphs (2017), respectively, further controlling for compensatory strategies. Other studies have tested recognition of complex emotional facial expressions, often in conjunction with basic emotions. For instance, Baron-Cohen et al. (1997) found no group recognition differences for basic facial emotions, but significant complex (i.e., scheming, guilt, thoughtfulness, admiration, quizzical, flirtatious, boredom, interest, arrogance) FER impairments for ASD participants. In a multinational examination of basic and complex emotion recognition in ASD and TD, Fridenson-Hayo et al. (2016) found complex emotion recognition impairments across all three sites but basic emotion recognition deficits in only two. Further, basic emotions were recognized better than complex (Fridenson-Hayo et al., 2016). Similar patterns of results have been found elsewhere (Sawyer et al., 2012; Walsh et al., 2016). It appears that decreasing the intensity of certain emotions or by using complex emotional stimuli may help to elicit FER differences in ASD.

Finally, further manipulations of task stimuli have found group FER differences. Occluding distinct areas of the face either through masking certain facial features has not only led to differential performance between ASD and TD controls, but has possibly suggested distinct facial processing patterns in ASD. For instance, Hobson and colleagues (1988) compared FER in ASD and TD controls for images of either whole-face (i.e., all features visible), masked-mouth, or mouth and forehead-masked stimuli. Interestingly, there were no group differences during the whole-face condition; however, ASD performance significantly dropped during the masked conditions (Hobson et al., 1988). Likewise, Baron-Cohen and colleagues (1997) found similar group FER performance for basic emotion with whole-face images followed by significantly poorer performance when only eyes were visible. Importantly, the authors noted that some ASD participants reported the ability to decode emotions from specific features, such as perceiving happiness or sadness from the mouth alone from the full face, which may explain poor performance in the eyes-only condition (Baron-Cohen et al., 1997). These results suggest that not only the presence of FER impairments under certain conditions, but possibly that these differences are related to atypical face processing.

Face Processing Differences. TD individuals are generally thought to process faces configurally, reflecting a human tendency to perceive the face as a gestalt and a sensitivity to the prototypal placement of facial features and their spatial relations (e.g., distance between them, shape; Maurer et al., 2002). In other words, faces are not processed based on the individual features, but the relationship between them as whole. This assumption has been supported through several tasks that are thought to disrupt this global processing, such as the Face Inversion task showing that TD face processing is slower and less accurate when viewing inverted faces (Maurer et al., 2002). Unsurprisingly, inversion effects have been found during processing of facial emotion expressions (Derntl et al., 2009). Nevertheless, research examining the processing of facial emotional expressions has suggested that elements of both configural and featural processing occur (Calvo et al., 2010; Tanaka et al., 2012). For instance, Calvo and colleagues (2010) showed an advantage for happy face recognition when configural processing was constrained, suggesting that distinct features associated with happiness (i.e., smiling mouth) were processed, and they provided accurate diagnostic information.

Similarly, Tanaka et al. (2012) showed that emotional faces are processed featurally when the whole face is either unavailable or shows conflicting, vague information. Implicit in these findings, is the notion that certain facial features and regions may be more diagnostic of certain emotions. Indeed, research has supported this notion, indicating that the bottom half of the face, particularly the mouth area, is more indicative of happiness, surprise, and disgust, while the upper half, the eye region, is weighted more heavily for recognition of anger, fear, and sadness (Bassili, 1979; Schurgin et al., 2014; Tanaka et al., 2012); however, Bassili (1979) suggested that sadness may utilize information from both top and bottom face halves. These results may explain some of the variable findings in the ASD FER performance literature.

There are several research findings that propose an atypical face processing style in ASD. For instance, Hobson et al. (1988) found no inversion effect in ASD adolescents when processing faces, with similar results found in other studies (McPartland et al., 2004; Tantam et al., 1989; van der Geest et al., 2002). This has been suggested as evidence of a lack of configural processing for faces in ASD (Sasson, 2006). However, there are somewhat conflicting results, indicating that ASD individuals may not lack configural face processing ability, but are possibly biased towards featural processing of faces (Lahaie et al., 2006; Teunisse & de Gelder, 2003). Together, these results may explain at least some of the FER performance variability in the literature. For example, Kätsyri and colleagues (2008) tested FER performance of happiness, anger, fear, and disgust in adults with ASD, using both high- and low-spatial frequency images which either allow or prevent featural processing, respectively. They found no FER differences when individual facial features were recognizable, but the ASD group performed significantly worse with low-resolution images, requiring greater configural processing (Kätsyri et al., 2008). Thus, a lack of differences in the literature may be evidence of a relative strength in featural processing, allowing accurate emotion recognition through picking up on the specific, salient facial features associated with certain emotions (e.g., smile for happiness, furrowed brow for anger). This would also explain why group differences emerge when experimenters masked certain facial features (e.g., Hobson et al., 1988).

Examining emotion recognition differences with simple accuracy-based performance studies has left the question of ASD differences in an equivocal state. Indeed, as individuals with ASD may perceive faces differently, it is likely that recognition accuracy does not tell the whole story. Nevertheless, research has turned to exploring other types of behavior involved in facial emotion perception that allow analysis at a more objective level (Harms et al., 2010). One area that has seen a growing literature base is the use of eye-tracking to examine eye gaze differences during facial emotion perception in ASD.

FER and Eye-tracking in ASD

Similar to the previously reviewed FER performance literature, several eye-tracking studies have shown atypical gaze behavior during facial emotion expression perception tasks, extending differences to the underlying cognitive mechanisms. Also, like performance findings, these differences have been shown across age groups, tasks, emotions, and stimuli.

For instance, atypical scanning patterns have emerged during labelling tasks. Pelphrey and colleagues (2002) compared TD and ASD adult eye-movements during a labelling task of happy, sad, angry, fearful, surprised, and disgusted emotions. They found a significantly smaller proportion of fixation time on the eyes and nose and a trend for greater fixation counts on the mouth in the ASD group. This resulted in a qualitatively different scan path of facial expressions between the groups. While the TD group tended to scan the region consisting of the core facial features (i.e., eyes, nose, and mouth) in a triangular fashion, the ASD group scanned a path comprising many non-core features such as the ear, upper forehead, or chin. Importantly, this pattern may have affected the finding of an overall lower emotion recognition accuracy in the ASD group. However, this was due mainly due to a significant difference in fear alone and near significant difference in anger. Considering the eye region provides the main diagnostic information for both anger and fear (Bassili, 1979; Schurgin et al., 2014; Tanaka et al., 2012), Pelphrey and colleagues' (2002) results suggest a possible overreliance on featural face processing in FER, potentially explaining both the presence and absence of FER differences. Specifically, reduced visual attention to the eyes might underlie reduced accurate recognition of emotions that rely on eye information (e.g., fear, anger) in the study, while increased fixations to the mouth may facilitate those emotions dependent on information in this area (e.g., happiness; Pelphrey et al., 2002).

Other studies have shown similar atypical gaze patterns for the eyes, mouth, or both in emotional facial expressions alongside FER deficits. For example, Bal and colleagues (2010) found significantly longer fixation times for non-core facial areas, as well as a tendency for longer mouth and shorter eye region fixations, in ASD children compared to TD controls. Likewise, findings have shown significantly shorter eye region fixation in adolescents (Bours et al., 2018; Dalton et al., 2005) and adults (Boraston et al., 2008; Corden et al., 2008); more eye-movements away from the eyes (Kliemann et al., 2012); shorter fixation durations for the face generally (Kirchner et al., 2011); increased fixation time for non-core face areas (Falkmer et al., 2011); fewer total eye fixations in adults (Falkmer et al., 2011); and nonsignificant trends for increased time fixating on the mouth (Bal et al., 2010; Corden et al., 2008). These results, along with reduced emotion recognition accuracy for anger (Bal et al., 2010), fear (Corden et al., 2008), sadness (Corden et al., 2008), as well as general, nonspecific deficits in basic (Falkmer et al., 2011; Kliemann et al., 2011) and complex emotions (Kirchner et al., 2012), strengthen the notion that atypical eye-movement behavior may underlie FER deficits in ASD.

Nevertheless, research has also found more variable and conflicting results, showing, for instance, atypical gaze patterns but no FER differences. Spezio et al. (2007a) found no FER performance differences between ASD and TD adults; however, gaze behavior differed in filtered (i.e., lower featural resolution) but not unfiltered faces. Likewise, Rutherford and Towns (2008) found shorter fixation durations on core facial features (i.e., mouth, eyes) during FER performance for complex but not basic emotions. Leung et al. (2013) indicated similar FER performance in ASD and TD children, as well as a similar pattern of fixations (i.e., both groups fixated longer on eyes than other face regions), but the ASD group showed longer fixation durations within each face area.

Furthermore, other studies have failed to uncover significant differences in both gaze behavior and FER performance (McCabe et al., 2013) or showed typical gaze patterns but reduced FER accuracy (Sawyer et al., 2012; Wang & Adolphs, 2017).

It is possible that many of these results reflect facilitative effects of featural processing, as well as its breakdown in certain situations. For example, Kätsyri et al. (2008) found similar FER performance for full-resolution facial expressions but impairment when features were constrained. This may indicate that, at least some, ASD individuals can utilize specific facial features as a compensatory mechanism to decode emotions, possibly through specialized training and experience (e.g., Neumann et al., 2006; Spezio et al., 2007a). Thus, they may be looking at the same face areas as controls depending on the specific emotion, although this would reflect an explicit strategy rather than an automatic perceptual style. Moreover, some of the same previously reviewed factors potentially affecting FER performance outcomes may play a role in explaining variable eye-tracking outcomes. Eye-tracking results during social referencing tasks have shown similar overall fixation duration for specific face areas; however, the temporal sequence of respective group gaze behaviors differed, showing a predisposition to look towards faces, especially the eyes, sooner in TD individuals. Thus, extended stimuli presentation durations may actually mask true expression processing differences. Variable performance has also been related to heterogeneity within ASD, with a tendency to look at eyes associated with a better social skill subgroup while a better nonverbal communication subgroup tended to look more at the mouth (Falck-Ytter et al., 2010). Additionally, the explicit nature of FER task demands may affect the spontaneous gaze behavior of ASD participants, as prompts to attend to emotional content specifically have shown effects on emotion processing performance (Begeer et al., 2006; Weeks & Hobson, 1987).

Related to this last point several eye-tracking studies have utilized implicit tasks during facial expression processing. Studies using passive-viewing paradigm, in which the participant simply views the presented socioemotional content with minimal explicit direction, found scanning group gaze behavior differences. Klin and colleagues (2002) compared eye gaze behavior in ASD adolescents and young adults while viewing film clips of complex social-emotional interactions, showing significantly less time fixating on the eyes in the ASD group but significantly more time fixating on mouths compared to TD controls. This was replicated later with similar outcomes (Speer et al., 2007), while Hanley et al. (2013) also showed reduced eye-directed gaze behavior during similar social scenes. Hernandez et al. (2009) found that an increased fixation duration for external, non-core facial features in ASD adults compared to TD controls. They also noted that ASD participants began face processing in the mouth region, while the TD group began with eyes (Hernandez et al., 2009). Some researchers have found a possible lack of overall social saliency in ASD. Wang et al. (2015) reported atypical viewing patterns during presentations of naturalistic social scenes with increased gaze behavior towards background and non-social information, as well as faster fixations for non-social objects and increased latency for socially-related fixations. Similarly, low saliency for faces and longer latencies to fixate on the face were found in Riby and Hancock (2009).

In all, ASD appears to be characterized by an atypical facial expression processing style that may affect the accurate perception of at least some expressions.

In sum, the literature surrounding FER in ASD is quite variable in its findings of impairments and possible underlying mechanisms. FER performance deficits have been reported across several studies, spanning multiple ages, tasks, and stimuli (e.g., Philips et al., 2010; Tantam et al., 1989; Walsh et al., 2016); however, inconsistent findings exist (e.g., Castelli, 2005; Høyland et al., 2017), although several possible confounding factors may underlie these null findings (e.g., age, IQ, stimuli type; Harms et al., 2010). Going beyond simple behavioral performance measures, eye-tracking technology has been utilized to explore possible underlying cognitive and neural mechanisms of FER differences, such as a potential face processing difference. Like FER performance results, several examples of atypical gaze behavior for facial expressions are reported (e.g., Boraston et al., 2008; Bours et al., 2018) as are contrasting findings (e.g., McCabe et al., 2013). Nevertheless, the literature tends to suggest a FER impairment in ASD (Uljarevic & Hamilton, 2013) that may be related, in part, to atypical facial information processing. However, faces are not the only nonverbal cue that humans use to decode others' emotional states. Bodies are another important, and possibly necessary, area for emotion recognition. This topic is discussed next.

TD Bodily Emotion Recognition

Facial expressions have long dominated the emotion recognition field, comprising the vast majority of research (de Gelder, 2009) and most likely stemming from Ekman and Friesen's (1971) seminal findings suggesting universal recognition of the basic emotions. However, research has continued to show that bodily expressions are not simply supplementary to faces but viable, accurate, and important sources of emotion perception for social functioning (de Gelder, 2009).

Indeed, many of the characteristics commonly associated with FER are present in bodies as well. For instance, Sogon and Masutani (1989) demonstrated accurate bodily emotion recognition (BER) in a sample of both TD American and Japanese participants. Almost a decade later, Wallbott (1998) showed that certain body postures and movements alone could provide diagnostic information for recognition of specific emotions. Emotion development research has indicated that accurate BER is present in TD children as young as four-years-old (Boone & Cunningham, 1998). TD humans also appear to process bodies configurally (Atkinson et al., 2007; Reeds et al., 2012). Furthermore, Atkinson and colleagues (2004) demonstrated intact BER in the absence of both movement and a visible, human body when bodily emotions were presented either statically or dynamically and either in full-light displays (i.e., whole body visible) or point-light displays (PLDs; i.e., only the most basic figural information from lights attached certain areas). While the research is clear that bodies can provide the same social-emotional information as faces, focusing research solely on one modality may prove shortsighted. Humans typically do not encounter one without the other in the natural world. Thus, it may be safe to assume that faces and bodies contribute unique, as well as shared, importance to emotion recognition, and the literature appears to support this idea.

Increasingly, research has pointed to the importance of examining emotion expression recognition with compound face-body emotional expressions (FBEEs), indicating when information from each area is integrated, the processing and recognition of emotion can be affected in many ways. To illustrate, Martinez et al. (2016) compared emotion recognition performance in TD adults from either facial or bodily expressions alone or from FBEEs and found overall higher recognition accuracy for FBEEs, suggesting that more cues may lead to better decoding. Similarly, Aviezer et al. (2012) reported that faces alone may fail to communicate information from intense emotional expression such as when losing an athletic competition. Rather bodies, in conjunction with facial information, guide how the observer ultimately judges the emotional content (Aviezer et al., 2012). Further, findings from congruent-incongruent FBEE tasks have provided further support for the importance of FBEE research. Here, researchers pair a facial emotion with either a congruent or incongruent bodily emotion, typically examining the combined effects on FER performance. Findings have generally indicated that incongruent emotional information from the body affects FER performance (Aviezer et al., 2008; Aviezer et al., 2012; Hietanen & Leppanen, 2008; Mondloch, 2012; Nelson & Mondloch, 2017) and biases judgment towards the emotion expressed in the body (Meeren et al., 2005; Nelson & Mondloch, 2017, Van den Stock et al., 2007). Moreover, this same effect is seen when the information presented in the face and body is perceived as ambiguous (Nelson & Mondloch, 2017; Van den Stock et al., 2007) and even when bodies are not consciously attended (Hietanen & Leppanen, 2008; Mondloch, 2012; Nelson & Mondloch, 2017), suggesting an underlying mechanism subserving the automatic integration of facial and bodily expressions. Together, these findings further suggest that humans are predisposed to viewing and processing information from both faces and bodies.

Eye-tracking results with compound expressions suggest that examining emotion expression recognition multimodally may lead to a more robust understanding of emotion recognition in humans. Aviezer and colleagues (2008) recorded eye movements while TD adults viewed congruent or incongruent anger and disgust FBEE pairings. Importantly, they found that incongruent face-body pairings influenced the visual scanning of facial emotions, reducing the typical preference for eyes in angry faces and mouth in disgusted faces seen in congruent contexts (Aviezer et al., 2008). Similar findings of altered visual attention patterns for incongruent pairings have been found elsewhere, showing that certain compounds alter gaze differentially to the face or body area. For instance, Nelson and Mondloch (2017) showed increased visual attention to the face during incongruent stimuli, except for fearful face—angry body pairs, suggesting a facilitative effect of anger. Similarly, Kret and colleagues (Kret, Roelofs, et al., 2013; Kret, Stekelenburg et al., 2013) found increased attention toward both angry and fearful expressions regardless of modality, suggesting possible evolutionary adaptations to these facilitative effects. It appears that emotion recognition research is incomplete without the inclusion of bodies. Fortunately, bodies, either in isolation or together with faces, have increasingly been included in the TD research. Likewise, ASD emotion recognition research has followed suite.

Emotion Recognition and Bodies in ASD

Like the FER literature, researchers have found mixed results regarding BER impairments in ASD, showing both the presence and absence of deficits across ages, tasks, and stimuli. For instance, Moore et al. (1997) used dynamic PLDs of basic emotions (i.e., happy, sad, angry, and afraid), actions (e.g., climbing, pushing, and lifting), and subjective internal states (i.e., itchy, tired, cold, and hurt) to examine recognition differences in 13 ASD children and adolescents compared with 13 verbal IQ (VIQ)-matched TD and 13 age- and VIQ-matched ID controls. There were no differences between the ID and TD groups' abilities to accurately label observed emotions, subjective states, and actions. However, the ASD showed poorer performance for basic emotions and itchy body expressions relative to both control groups. Conversely, they found no ASD weakness when recognizing action expressions (Moore et al., 1997). Hubert and colleagues (2006) found similar results in 19 ASD adolescents and adults compared with 19 age- and sex-matched TD controls with the same paradigm, indicating impaired BER performance in the ASD group but not action or subjective state recognition. Likewise, Hadjikhani and colleagues (2009) found comparable performance results in 11 ASD adults relative to 11 TD controls during a forced-choice, match-to-sample task of static body expression (i.e., sadness, anger, fear) and actions (e.g., pouring a drink, talking on phone) images. Results indicated that the ASD group showed higher action recognition accuracy relative to both controls and within-ASD group emotion recognition performance, while TD participants showed the opposite pattern (Hadjikhani et al., 2009). However, this pattern may not always be the case.

Nackaerts and colleagues (2012) found that 12 ASD adults were less able to both label non-emotional PLDs as either human motion or not or to label the emotions depicted from PLDs (i.e., happy, sad, angry) compared to 12 TD adults. Recently, using computer-generated dynamic displays of bodily emotions, Metcalfe et al.(2019) found that 27 ASD children were less accurate than age- and sex-matched TD controls when labeling basic and complex (i.e., bored, worried) emotions. Together, these results suggest a possible BER impairment in ASD; however, this deficit appears to mostly affect emotional information as bodily action recognition is spared, or even enhanced, compared to controls, although this is still up for debate (e.g., Nackaerts et al., 2012; Pavlova, 2012)

Nevertheless, as with the FER literature, some findings have indicated no or variable BER performance differences between ASD and control groups. In a forced-choice labeling task, Atkinson (2009) compared BER accuracy in 13 TD and 13 ASD adults matched for age, full-scale IQ (FSIQ), VIQ, and nonverbal IQ (NVIQ) while observing dynamic PLDs and traditional film clips of emotional (i.e., angry, happy, sad, fearful, disgusted), instrumental (e.g., digging, kicking), and non-instrumental (e.g., walking, hopping) bodily expressions. Results showed better TD recognition of happy, angry, and disgusted but not sad and fearful expressions. Additionally, the TD group initially showed better action recognition relative to the ASD group, although differences did not statistically survive corrections for multiple comparisons across stimulus (e.g., PLDs) and action (e.g., instrumental) types. Nevertheless, there was a trend for better ASD recognition of instrumental versus non-instrumental action recognition (Atkinson, 2009).

Later, Doody and Bull (2011, 2013) showed variable ASD emotion recognition performance across task types. They compared BER recognition accuracy and reaction times (RTs) during forced-choice labeling and match-to-sample tasks of animated images of complex (i.e., bored, interested, agreeing, disagreeing; Doody & Bull, 2011) and basic (Doody & Bull, 2013) emotional bodily expressions in 20 ASD and 20 TD adolescents matched for age, FSIQ, VIQ, NVIQ, and visual-perceptual ability. Accuracy results indicated no group matching differences for either basic or complex emotions but lower ASD labeling performance for bored and fearful expressions. Additionally, TD participants were faster when matching angry and all complex expressions, as well as when labeling bored and interested expressions. Considering intact matching but variable labeling performance and longer RTs for certain emotions, the authors suggested that this pattern may reflect a reliance on featural processing, as well as the possibility that ASD individuals recognize the relationship between bodily expressions and internal states but may not be able to actually understand the cues (Doody & Bull, 2011, 2013).

Importantly, several researchers have begun to include both faces and bodies in their examinations of emotion recognition in ASD with a range of findings. Although many of these studies continue to present emotions from each modality in isolation (i.e., faces alone, bodies alone), the inclusion of both is important, reflecting the growing acknowledgement that emotions are not communicated solely from the face. For instance, Philip and colleagues (2010) examined emotion recognition from isolated bodies, faces, and voices in 23 ASD adults and 23 age- and sex-matched TD controls. Participants completed forced-choice labeling tasks during film clips of happy, sad, angry, afraid, and disgusted emotional bodily expressions, audio clips of emotional vocal expressions, and static images of facial expressions, as well as a forced-choice match-to-sample facial expression task. The authors found better TD labeling performance across emotions in body and voice expressions and for angry, sad, and fearful facial expressions, as well as when matching sad facial expressions (Philip et al., 2010). Fridenson-Hayo et al. (2016) extended these findings by including isolated, as well as combined emotional expression modalities. In a forced-choice labeling task using clips of isolated facial, bodily, vocal expressions and integrated (i.e., combination of three modalities) expressions, the authors compared recognition accuracy between 55 ASD children and 58 age-, IQ-, and sex-matched TD controls. The researchers found poorer ASD recognition performance relative to TD controls across all modalities (Fridenson-Hayo et al., 2016). By examining several modalities at once, these findings lend support to the notion global emotion recognition impairments in ASD.

Despite these findings, other researchers have shown more equivocal outcomes when examining emotion recognition from both faces and bodies. In their latter study, Doody and Bull (2013) included static animations of isolated facial expressions, finding no group FER differences in either recognition accuracy or RT. Similarly, Peterson and colleagues (2015) compared both body and face emotion recognition accuracies in children. In their first study, 34 ASD children and 41 age- and VIQ-matched TD controls completed forced-choice labelling tasks to assess their BER performance of the six basic emotions from body expression images and their FER performance of a range of basic (i.e., sad, fearful) and complex (e.g., kind, friendly, worried) emotions from images of just the eye region. In their second study, 33 ASD children and 31 age-matched TD controls completed the same tasks except the eye regions depicted the six basic emotions only. Results indicated no group BER differences, but the TD group showed higher FER accuracy in both studies (Peterson et al., 2015). It is important to note, however, FER comparisons may have been different had the whole face and not just eyes been available, considering the research indicating less visual attention for eyes in ASD (e.g., Bal et al., 2010; Bours et al., 2018). Regardless, these findings further demonstrate the variability in ASD regarding emotion recognition and the difficulty in determining the presence or extent of emotion recognition impairments. Moreover, as none of the studies reviewed here have directly compared FER and BER performance, it is impossible to conclude if one is a relative strength for the ASD population. Nevertheless, research has begun to examine more nuanced bodily emotion perception behavior in ASD.

Considering the presence of findings pointing to differential use of emotional cues from the face or body in the TD population (e.g., Aviezer et al., 2012; Meeren et al., 2005), as well as reports of atypical processing styles of faces in ASD (e.g., Hobson et al., 1988; Kätsyri et al., 2008), these areas may also play a role in ASD bodily emotion perception. For example, Actis-Grosso et al. (2015) showed PLDs of isolated happy, sad, fearful, angry, and non-emotional (e.g., walking, riding bike) bodily expressions and static images of isolated happy, sad, fearful, and angry facial expressions to 20 ASD and 25 TD adults. Results indicated that the TD participants attended more to bodies for fearful expressions but the face for sad expressions, while the ASD group looked at the face more regardless. This suggests that TD individuals are able to employ a flexible socioemotional perceptual style, directing attention to the most diagnostic modality depending on the emotion. Conversely, this was not true for ASD participants who decoded emotions more from the face regardless, despite the ability to accurately decode meaning from body movements, as evidenced by comparable action recognition levels. The authors noted that the lack of differentiation in ASD may be due to prior training and compensatory learning that weights the facial region more heavily (Actis-Grosso et al., 2015), possibly be due to the ability to decode expressions via featural processing. Similarly, Doody & Bull (2011, 2013) noted that longer RTs but higher accuracy during matching versus labeling of bodily expressions were reflective of possible featural processing.

Nevertheless, Brewer and colleagues (2017) found that adults with ASD can and do attend to bodily information when making emotion perception decisions, noting evidence of configural processing behavior when observing FBEEs. Specifically, 19 ASD adults and 27 age-, IQ-, and sex-matched TD controls viewed static images depicting faces along an anger-disgust continuum either in isolation or attached to bodily expressions in congruent or incongruent pairings. They then categorized the emotion in the face alone. Results indicated no overall group differences in either accuracy or susceptibility to bodily information; however, there was a proportion of ASD participants with significantly lower isolated face categorization performance. Moreover, these same ASD participants showed greater body interference effects. In other words, while both groups were susceptible to categorizing based on bodily information in certain contexts (e.g., when facial emotions were vague) despite instructions to ignore the body, those who had the worst face-only performance showed greater body interference effects. Importantly, these findings further demonstrate the variable emotion recognition performance with ASD, while also indicating that ASD individuals do attend to bodily emotion information. Further, individuals with less developed FER skills may preferentially attend to the body (Brewer et al. 2017). Thus, when individuals with ASD have poorer FER skills or enter into situations with complex, vague facial emotional information that exceeds their current knowledge, they may look to other sources such as the body. Without proper understanding of emotional body expressions, as posited by Doody and Bull (2011, 2013), their social skills and interpersonal interactions may suffer. Augmenting their emotion recognition skills from multiple sources may shift their differential use of FER (e.g., Actis-Grosso et al., 2015) to more typical styles or allow them to compensate in complex situations.

In sum, the notion of BER deficits is unclear at the moment. While several studies show BER deficits in ASD, conflicting and variable results exist, possibly affected by methodological issues. When significant differences have been found, they appear specific to emotion processing rather than a global processing deficit for body information. Moreover, some research suggests that bodies are attended to, sometimes similarly to TD controls, but that understanding of that emotional content from bodies is lacking. Further research is necessary to clarify the state of BER in ASD. Nevertheless, examination of emotion recognition performance alone may not be enough to shed light on this subject, especially considering as multiple findings suggest underlying processing style differences.

Eye-tracking with Bodies in ASD

Few emotion perception eye-tracking have included bodies. Nackaerts and colleagues (2012) recorded ASD and TD adult participants' eye movements while viewing PLDs of emotional and non-emotional bodily expressions. They found s significantly more saccades and shorter fixation durations in the ASD group across stimuli type; however, atypical eye movements were only statistically related to emotion recognition performance, showing better performance related to longer fixations and fewer saccades (Nackaerts et al., 2012). These eye gaze patterns may indicate a reliance on featural processing, as well as suggesting that bodily areas may not provide diagnostic information about the underlying emotion observed in ASD. In turn, individuals with ASD may search more for this information, leading to more saccades and shorter fixations. While Nackaerts et al. (2012) showed evidence of atypical gaze behavior for emotional body expressions, they did not explore specific differences about where and how the groups looked, such as to what body parts during observation of certain emotions. Extended research in this area can help indicate whether those with ASD look at the same places (e.g., arm, leg) for a similar overall proportion of time but through many quick fixations as TD individuals or observe bodies categorically different.

While other studies have included stimuli with bodies in eye-tracking experiments, faces remain the target of analysis. Thus, bodies are often treated as single AOI, prohibiting more specific analyses of differences within bodily regions. These studies also tend to focus on overall social attention rather than emotion perception. Nevertheless, results from these examinations are important to consider.

Studies using passive viewing paradigms have shown differences in ASD attention to bodies and faces relative to controls. For instance, Klin and colleagues (2002) showed film clips of complex socioemotional interactions to 15 ASD adolescents and 15 age- and VIQ-matched TD controls. The authors examined the proportion of total fixation time spent viewing four AOIs (i.e., mouth, eyes, body, other) and found longer ASD fixations on body, mouth, and other areas, while the TD controls looked longer at the eyes. Speer and colleagues (2007) showed similar results in 12 ASD adolescents and 12 age-, VIQ-, NVIQ-, and sex-matched TD controls when viewing isolated (i.e., one actor) and social (i.e., two or more actors) static images and film clips. Results indicated differences for social film clip only. The TD group looked significantly longer at the eyes, while the ASD participants looked longer towards the body, although this difference only approached statistical significance. There was a similar trend for static images as well (Speer et al., 2007). Likewise, Riby and Hancock (2009) showed similar results across dynamic and static images of both human and cartoon stimuli involving multiple characters interacting. Specifically, fixation durations of 20 ASD adolescents were compared with 72 TD controls subdivided into age-matched or NVIQ-matched groups. Compared to either age- or NVIQ-matched controls, ASD participants looked longer towards the body and shorter towards the eyes when viewing cartoon images or human film clips. Further, age- and NVIQ-matched controls looked longer at the face during cartoon images and film clips of both cartoon and human actors (Riby & Hancock, 2009).

Interestingly, this gaze behavior pattern may be related to task demands. Hanley and colleagues (2013) examined fixation duration in 14 ASD adults and 14 TD controls matched for age, VIQ, NVIQ, and sex. Participants observed images of basic and complex (i.e., excited, sorry, romantic, bored, thinking) facial emotions, as well as acted (i.e., exaggerated facial expressions from film clips) and naturalistic (i.e., facial expressions from film clips of social interactions). Acted and naturalistic images were also presented in either isolated contexts (i.e., only one person) or during social interaction (i.e., two people present). Bodies, or portions of bodies, were present in all images. The authors indicated that for social acted and naturalistic scenes only, ASD participants fixated on the body more compared to TD controls. Conversely, the TD group looked at the face and eyes more during naturalistic social scenes and the eyes only during acted social scenes, suggesting that increased social-emotional complexity affects visual attention (Hanley et al., 2013). This may also be consistent with Brewer and colleagues' (2017) results, in which increased body interference effects were seen in ASD individuals with poor FER for ambiguous facial expressions.

Based on these results, individuals with ASD may show a preference for attending to bodies, at least during passive-viewing tasks of complex social interactions. However, a lack of fine-grained analysis for specific bodily regions precludes examining where individuals look when they preferentially attend bodies, as well as comparisons to TD controls during body-directed gaze.

Summary of Emotion Recognition Literature in ASD

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 expressions of emotion alone as a viable source of information, sufficient for emotion recognition, while recent findings indicate that bodies are important for a more accurate understanding of emotion recognition in general. Interest in emotional bodily expression recognition in ASD has increased, but results remain unclear, indicating conflicting results of impairment in ASD. However, eye-tracking data during observation of complex, interactive social contexts have suggested a possible visual attention preference for bodies in ASD (see table 1 in Appendix A for summary of BER findings). Interestingly, BER assessment results have shown possible intact perception for non-emotional body expressions in ASD, despite impaired emotional perception.

The reasons for these latter findings are unclear at the moment. However, given the presence of emotion recognition impairments in at least some of those with ASD along with core social deficits, as well as the knowledge that emotions can be successfully decoded from body, these behavioral patterns may provide a springboard for better individualized interventions and compensatory learning. Indeed, current emotion recognition intervention programs focus on the face almost exclusively (e.g., Berggren et al., 2018; Bölte et al., 2006; Tanaka et al., 2010); however, there is debate about their general effectiveness in augmenting social skills outside the training session, reflecting possible generalizability issues. Thus, for those ASD individuals who preferentially attend to bodies and/or show intact non-emotional body perception, interventions may be more effective if they build on this strength. Nevertheless, to do this research must continue to examine what areas are most effective and efficient for feature-based emotion recognition from bodies, as well as face-body compounds because. Although some ASD individuals may preferentially attend to bodies over facial areas, they may not exclusively attend to the body.

Pilot Study

From the literature reviewed thus far for the originally planned study, it is apparent that BER is an understudied area in TD, as well as clinical, populations. And much like the ASD emotion recognition research, faces have played the dominant role in the TD domain (de Gelder, 2009). As such, further research surrounding bodily emotion processing is needed to expand the literature base relative to faces generally and to fill in gaps in understanding more specifically. In this vein, the pilot study explored emotion recognition in TD children between the ages of 7 and 11 years, focusing on BER performance, their eye movements during emotion recognition tasks, and how their BER performance related to their social-emotional functioning.

Bodily Emotion Recognition Ability

Literature examining the developmental trajectory of bodily emotion processing in TD people is limited but suggests that discrimination among bodily emotions is present within the first year of life. Missana and colleagues (2015) found event-related potentials (ERPs) in emotion-specific brain areas following happy and fearful dynamic PLDs for 8- but not 4-month-old infants. In a behavioral study, researchers explored bodily emotion processing in 6.5-month-old infants (Zieber et al., 2014). Infants showed a preference for happy expressions when shown simultaneous displays of dynamic happy bodily expression and non-emotional, neutral actions (e.g., digging a hole). In a second experiment, infants heard a vocal expression of either happiness or anger while shown side-by-side displays of dynamic happy and angry bodily expressions. Based on their significantly greater looking time to and preference for congruent voice-body pairs, the authors suggested that early stages of BER were present by 6.5 months (Zieber et al., 2014). With the same paradigm, Heck et al. (2018) found similar results for voice-body pairs in 5-month-olds but not 3.5-month-olds. In all, the early body emotion processing literature shows similar trends to faces, wherein infants show an early preference for happy faces (Farroni et al., 2007) and continue to develop early FER abilities across the first year (Nelson & Dolgin, 1985; Serrano et al., 1992; Soken & Pick, 1999).

Following infancy, the limited BER developmental literature continues to resemble FER findings, such as protracted emergence of FER for certain emotions and improvement across development (e.g., Herba et al., 2006; Vicari et al., 2000). For example, Witkower et al. (2020) examined the emergence of accurate BER for static images of sadness, anger, and fear in children between three and eight years, finding that sad BER appears to emerge first followed by fear then anger, as well as age-related BER improvements across emotions. Nelson and Russell (2011) compared BER and FER performance for dynamic bodily and facial expressions of happiness, sadness, fear, and anger across three-, four-, and five-year-old children and adults. They found an age effect on accuracy that showed improvement for fear, sadness, and anger recognition, as well as an emotion effect, showing better happy, sad, and angry recognition compared to fearful expressions. In addition, children, but not adults, showed significantly better FER than BER performance, suggesting that the two modalities become more comparable across development (Nelson & Russell, 2011). Later, Ross et al. (2012) compared BER of dynamic PLDs and FLDs of happiness, sadness, anger, and fear across 4-17-year-old and adult participants. They found a significant improvement with age, although adults were still significantly more accurate than all youth age groups. Further, there was a steep improvement period between four and eight and one-half years that levels off dramatically into adolescence (Ross et al., 2012).

In all, it appears that TD individuals possess BER skills and that these skills emerge early in life and continue to improve with age, akin to FER development. Nevertheless, much of the BER literature focuses on adults (e.g., Atkinson et al., 2004, 2007; Avezier et al., 2012; Coulson, 2004; de Gelder & van den Stock, 2011; Martinez et al., 2015; Sogon & Matsutani, 1989). While developmental findings exist, the research reviewed here focuses mostly on young children and when viewing dynamic displays with the exceptions of Ross et al. (2012) and Witkower et al. (2020), respectively. There is evidence to suggest that FER is more accurate than BER in younger children (Nelson & Russell, 2011); nevertheless, findings in older individuals, such as adults, are less clear (Actis-Grosso et al., 2015; Avezier et al., 2012; Meeren et al., 2005). To further complicate matters, sex differences showing a female recognition advantage have been found in some (e.g., Montirosso et al., 2009) but not all (e.g., Dunsmore et al., 2008) FER research. Although Parker et al. (2013) found a lack of BER sex differences, their study focused on younger children than those included in the pilot study.

In all, the pilot study sought to expand the BER literature, as well as explore possible age and sex effects in BER performance. Additionally, static rather than dynamic stimuli were used. Although several studies used dynamic stimuli, static images may provide unique knowledge about specific posturing in BER that may be masked by movement in dynamic displays (Witkower & Tracy, 2019).

Bodily Emotion Recognition and Gaze Behavior

As mentioned above, TD humans tend to visually process bodies and faces in a configural manner (Atkinson et al., 2007; Maurer et al., 2002; Reeds et al., 2012), with distinct facial and bodily areas and postures providing uniquely diagnostic information for certain emotions (e.g., Calvo et al., 2010, Wallbott, 1998). In faces, for instance, the eyes, nose, and mouth areas have been implicated in accurate FER across emotions. Additionally, certain emotions may be more or less related to information in certain regions (e.g., the mouth in happy, the eyes in anger; Calder et al., 2000; Smith et al., 2005; Wegrzyn et al., 2017). Further, distinct posturing of certain features (e.g., upturned corners of mouth in happiness) helps distinguish among emotions that draw from similar areas (Calder et al., 2000; Smith et al., 2005).

Likewise, upper body areas (e.g., torso, arms, hands) in particular appear to be most important when encoding and decoding bodily emotion expressions (Atkinson et al., 2004, 2007; Coulson, 2004; Witkower & Tracy, 2019), and, like faces, certain upper body areas may be more connected to certain emotions. For instance, Ross and Flack (2019) found that TD adults' BER performance for angry and fearful expressions dropped significantly when hands were masked while viewing static images but not for happy, sad, or surprised body expressions. Additionally, specific posturing of body areas further distinguishes emotions expressed in the body. Researchers often determine this by creating several postural combinations and then showing them to viewers who rate them according to which emotion is observed. Researchers examine observers' ratings, looking for high levels of agreement between specific postures and ratings of specific emotions. Results have shown unique posturing for the emotions in the pilot study, including anger (e.g., downward head tilt, expansive limb posturing with the arms raised and forward, fists clenched, and a forward lean), happiness (e.g., upward head tilt, expansive posturing with chest and arms out and up), sadness (e.g., downward head tilt, collapsed upper body posture, arms brought up with head/face in hands or arms and hands by sides), and fear (e.g., collapsed upper body, arms/hands in front of body and face, backwards lean; (Atkinson et al., 2004; Coulon, 2004; Wallbott, 1998; Poyo Solanas et al., 2020; Witkower & Tracy, 2019).

From this, eye-tracking technology has provided a method for deeper examination of nonverbal emotion expression recognition. Again, the research base leans heavily on facial expressions. Schurgin et al. (2014) showed that TD adults' eye movement patterns mirror the behavioral visual processing research above. Participants focused more overall on the core facial features (i.e., eyes, mouth, nose) across emotions, while looking at the eyes in angry, sad, and fearful expressions and the mouth for happy and disgusted expressions. Similar findings are found in other adult FER and facial emotion processing eye-tracking studies (e.g., Blais et al., 2017; Calvo et al., 2018; Peterson & Eckstein, 2012; Wegrzyn et al., 2017). Moreover, some researchers have shown that gaze patterns during facial emotion processing relate to accurate emotion recognition (Vaidya et al., 2014).

Similar to faces, eye-tracking during body emotion processing tasks has generally shown greater visual attention to core diagnostic areas on the body. Pollux et al. (2019) examined TD adults' eye movements during BER tasks with either static or dynamic angry, happy, sad, fearful, and neutral expressions. Across stimuli, participants' accuracy for all emotions was above 80%, but accuracy was higher overall for dynamic displays. Also, different accuracy patterns emerged within static (angry > happy, neutral > sad, fearful) compared to dynamic (angry, happy, fearful, neutral > sad) tasks. In addition, participants fixated on the head, torso, and arm regions during both tasks more than legs, consistent with the putative upper body dominance in emotional body expressions. Interestingly, participants devoted little visual attention to the hands; however, the authors offered no explanations as to why (Pollux et al., 2019). Kleinsmith and colleagues (2019) found similar results during a BER task of dynamic 3D avatars expressing complex (i.e., triumphant, frustrated, defeated) and neutral emotions. In their study, adult participants fixated longer and more often on the torso, head, and arm regions compared to legs, supporting the notion that the upper body is more diagnostic for BER, although hands were unavailable due to the stimuli used (Kleinsmith et al., 2019).

It is clear that the eye-tracking literature is heavily weighted for faces in emotion expression recognition; however, children's eye movements and related developmental changes appear underrepresented in both FER and BER. Considering there is behavioral research to suggest a developmental shift in which facial features are most informative for TD individuals during childhood and adolescence, more research is needed (Karayanidis et al., 2009). It is possible that similar shifts exist during the development body emotion processing. Additionally, sex effects have been found during eye-tracking of FER tasks, showing increased gaze towards the eyes in adult females (Hall et al., 2010; Nakano et al., 2010), but there is a dearth of literature in this area for children and bodies. From this, the pilot study explored age and sex differences related to eye movements during both FER and BER.

Emotion Recognition and Its Relationship with Social-Emotional Functioning

Emotional intelligence or competence comprises several adaptive emotion-related abilities, including emotion knowledge, regulation of emotions and behaviors, and using emotions adaptively (Izard et al., 2011; Lemerise & Arsenio, 2000; Salovey & Mayer, 2001). Emotion knowledge comprises related aspects of emotion understanding such as recognizing emotions in oneself and others, as well as understanding more complex aspects such as the function of emotions (i.e., the connection between emotions and motivational states) and the antecedents and consequences of emotions in social-emotional situations and various contexts (Izard et al., 2011; Lemerise & Arsenio, 2000; Salovey & Mayer, 2001). From this, emotion knowledge, in particular emotion recognition (e.g., FER and BER), may provide a base layer upon which other emotional competencies build and thus inform broader social-emotional functioning (Barret et al., 2001; Denham et al., 2003; Lemerise & Arsenio, 2000; Izard et al., 2011). In other words, emotion recognition informs emotion knowledge, which, in turn, subserves adaptive, effective, and appropriate social-emotional functioning (e.g., self-regulation, emotion use, social skills, coping skills). Conversely, when individuals lack emotion recognition skills and emotion knowledge more broadly, several negative, and likely interrelated, outcomes are possible. For instance, a child without adequate emotion knowledge may consistently misattributes peers' facial or bodily expression as angry and react by avoiding others or overt aggression. Without proper emotion knowledge to process the external situation and one's internal emotional experiences, effectively regulating emotion-motivated reactions may prove impossible, and continued avoidance or aggression may lead to an internalizing (e.g., anxiety, depression) or externalizing (e.g., conduct disorder) disorder (Lemerise & Arsenio, 2000; Izard et al., 2011; Mogg & Bradley, 1998; Segrin, 2000; Zeman et al., 2000).

Indeed, several researchers have found associations between emotion knowledge broadly and social-emotional functioning. Arsenio and colleagues (2000) found that preschoolers' emotion knowledge, as measured by a combination of FER and emotion situation perception (e.g., perceiving emotions within social-emotional events) performances, was related to greater peer acceptance and better social skills. Conversely, their results indicated that more aggressive preschoolers showed less emotion knowledge (Arsenio et al., 2000). Studies using a similar measure emotion knowledge have uncovered several associations with social-emotion functioning. In a rural sample of mixed low and middle SES children, first and second graders' level of emotion knowledge predicted levels of academic competence and problem behaviors (e.g., externalizing and internalizing behaviors, hyperactivity), as well as social skills (e.g., working well with others, making friends) and other regulatory abilities (e.g., self-control, attentional control) with social skills, in turn, predicting peer acceptance and ratings of classmates' positive and negative emotionality (Mostow et al., 2002; Trentacosta et al., 2006). Similarly, in children from Head Start programs, kindergarten levels of emotion knowledge predicted level of social problems in first grade (Shultz et al., 2001), and first grade levels of emotion knowledge predicted internalizing behaviors (e.g., loneliness, anxiety) in fifth grade (Fine et al., 2003), while participants' bias for perceiving anger in situations was related to aggressive behavior (Fine et al., 2004).

When FER has been disaggregated from other emotion knowledge indices, research has continued to find connections to multiple indicators of social-emotional functioning. Longitudinal findings have indicated that Head Start preschoolers' FER predicted later social skills, academic competence, and internalizing behaviors in third grade (Izard et al., 2001), and first graders' FER predicted internalizing behaviors in a community sample (Castro et al., 2018). Poorer FER has been found in boys at-risk for attention-deficit/hyperactivity disorder (ADHD) compared to healthy controls, which was associated with lower levels of social skills and higher levels of internalizing and externalizing behaviors (Kats-Gold et al., 2007). Likewise, some research suggests FER differences in other clinical disorders thought to be related to deficits in emotion competence, such as poorer overall FER in ASD (e.g., Uljarevic & Hamilton).

Additionally, FER differences have been seen in depression and anxiety, in which social-emotional deficits have been posited in their development (e.g., Mogg & Bradley, 1998*;* Segrin, 2000), although findings are variable. Children and adolescents with depression have shown poorer FER of anger and fear (Lenti et al., 2000) but also better recognition of anger and sadness (Ellis et al., 1997). Anxious adults better recognize fearful and angry faces in some studies (Surcinelli et al., 2006; Torro-Alves et al., 2016) but not others (Cooper et al., 2008). Studies of anxious children also show variability with some showing general FER deficits (Easter et al., 2005), deficits in FER of specific emotions (e.g., anger; Jarros et al., 2012), and no deficits (Demenscu et al., 2010). Despite the variability among findings, is clear that a relationship exists between FER, alone and incorporated into emotion knowledge measures, and aspects of social-emotional functioning; however, little research exists for BER.

In one study examining the relationship between BER and social-emotional functioning in preschoolers, Parker and colleagues (2013) found that BER performance predicted better social skills in boys but not girls. The authors did not find a relationship between BER and aggression (Parker et al., 2013). In a study of BER within a clinical population, adults with depression showed worse BER for happy expressions, but not other basic emotions, compared to healthy adults and adults in depression remission (Loi et al., 2013). However, no relationship emerged between BER performance and social-emotional functioning. (Loi et al., 2013). Clearly, research regarding social-emotional functioning and wellbeing in relation to BER alone and within broader emotion knowledge is lacking. To this end, the pilot study sought to expand research in this area by exploring possible relationships between BER and measures of positive and negative social-emotional outcomes.

CHAPTER III

METHODOLOGY

Originally Planned Study

Participants

Participants were to include 30 ASD and 30 TD university students, both recruited from Texas A&M University. As previous literature has shown that age and intelligence can affect emotion recognition results (Harms et al., 2010) and the higher prevalence of ASD in males compared to females (CDC, 2018), participants will be matched for age, VIQ, NVIQ, and sex. The TD students were to be recruited via campus-wide mailings, listervs, and marketing material, while the ASD group were to be recruited from the Texas A&M Spectrum Living Community, a campus-based living community dedicated to supporting ASD students at the university, as well as through the Office of Disability Services.

ASD participants were to be included in the originally planned study contingent on a formal diagnosis of ASD by a qualified licensed healthcare provider and an IQ above 70 as measured by the Wechsler Abbreviated Scales of Intelligence, Second Edition (WASI-II; Wechsler, 2011). TD participants were to be included contingent on the absence of elevated ASD symptoms as measured by the Social Responsiveness Scale—Second Edition (SRS-2; Constantino & Gruber, 2012). Additionally, participants were to receive compensation in the form of a gift card of $30 upon completion.

Measures and Instruments

Wechsler Abbreviated Scales of Intelligence, Second Edition. The WASI-II (Wechsler, 2011) is a brief measure of intelligence that has been used in previous related research (e.g., Fridenson-Hayo et al., 2016; Hadjikhani et al., 2009; Hanley et al., 2013). The WASI-II comprises two subtests to assess VIQ and two assessing NVIQ and provides an overall FSIQ estimate. The WASI-II is a valid measure with adequate test-retest reliability across composites ($r \geq 0.86$; Irby & Floyd, 2013; McCrimmon & Smith, 2013). Administering the WASI-II takes approximately 30 minutes.

Social Responsiveness Scale-Second Edition. The SRS-2 (Constantino & Gruber, 2012) is a 65-item rating scale, assessing social behavior deficits associated with ASD. The SRS-2 offers an overall impairment score, as well as subscale scores, including social awareness, social cognition, social communication, social motivation, and restricted and repetitive behavior (Constantino & Gruber, 2012). The previous version has been used in similar studies that examined the emotion recognition in ASD individuals (e.g., Bal et al., 2010; Speer et al., 2007). The SRS-2 offers four rating forms depending on the age group of the individual in question: Preschool Form (2.5 years – 4.5 years), School-Age Form (4 years – 18 years), Adult Form (19 years – 89 years), and Adult Self-Report Form (19 years – 89 years). For the purpose of the originally planned study, it was planned that participants would complete the adult self-report form, regardless if they are between 18 and 19 years. The SRS-2 shows adequate internal reliability ($r = 0.88$ to 0.95), as well as adequate validity (Bruni, 2014). Items come in the form of statements, and respondents rate how much that particular statement describes the target individual's behavior on a four-point Likert scale (i.e., not true, sometimes true, often true, always true). The SRS-2 takes approximately 15 minutes to complete (Constantino & Gruber, 2012).

Self-Reported Emotional Intelligence Test. The self-reported emotional intelligence test (SREIT, Schutte et al., 1998) is a 33-item questionnaire that assesses a person's emotional intelligence. The SREIT is based on Salovey and Mayer's (1990) model of emotional intelligence, comprising the understanding and expression of emotions in one's self and others, emotion regulation, and emotion utilization. Initial construction of the SREIT showed it to be a valid measure of emotional intelligence, with adequate internal ($r = 0.90$) and test-retest reliabilities ($r = 0.78$; Schutte et al., 1998). Subsequent factor analyses of the SREIT have indicated four factors, including overall emotional intelligence, emotion perception, self-emotion regulation, and utilizing emotions (for further review see Schutte et al., 2009). Previous research has shown that self-reported ratings of emotion perception are related to objective emotion recognition performance (Austin, 2004, 2005; Bisch et al., 2016; Ciarrochi et al., 2001; Edgar, McRorie, & Sneddon, 2012; Hakenan, 2004). Items come in the form of statements, and participants rate how much that particular statement describes their behavior on a five-point scale from 1 (strongly disagree) to 5 (strongly agree). Scores range from 33 to 165 with higher scores representing higher levels of emotional intelligence. The SREIT takes approximately 5 minutes to complete (Schutte et al., 2009).

Social-Emotional Expertise Scale. The Social-Emotional Expertise (SEE) Scale is a recently developed scale, measuring individual differences in respondents' social cognition and behavior (McBrien et al., 2018). The SEE Scale consists of 25 items.

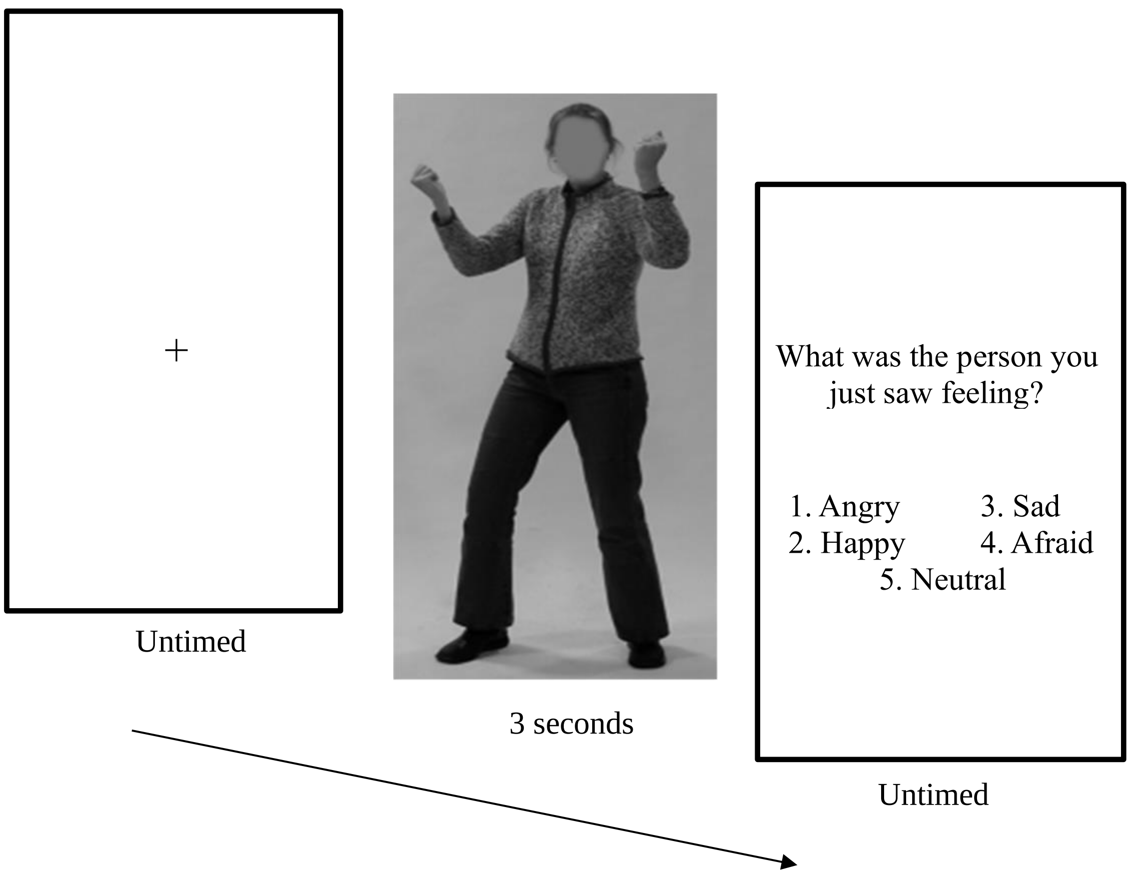
Items come in the form of statements, and respondents rate how closely each item describes them on a five-point Likert scale from 1 (never) to 5 (always). McBrien and colleagues (2018) reported adequate test-retest reliability ($r = 0.80$) and validity. Despite its newness and lack of use in other studies, the SEE Scale is an appealing measure for the current research due to its focus on decoding and using one's own and others' nonverbal emotional information in social situations. Thus, the SEE Scale is well situated to add additional information about how the participants perceive their own emotion recognition abilities compared to objective performance. The SEE Scale takes approximately 5 minutes to complete.

Symptom Assessment-45. The Symptom Assessment-45 (SA-45; Davison et al., 1997) is a brief screener of current psychiatric symptomology. Participants complete 45 items on a five-point Likert scale, assessing how severely each symptom has affected them in the past seven days. Items correspond to nine psychiatric subscales: depression, anxiety, hostility, interpersonal sensitivity, obsessive-compulsive, paranoid ideation, phobic anxiety, psychoticism, somatization. The SA-45 has shown adequate internal reliability (r = 0.71-0.92) and validity (Maruish, 2004). The SA-45 should take approximately 10 minutes to complete.

Eye-tracking Tasks. It was planned that participants would complete three, forced-choice labelling tasks to assess their emotion recognition: body-only, face-only, and face-body. Each task is identical except for the specific emotional stimuli present. Simultaneously, their eye movements would be recorded. Specifically, the participant would be shown a fixation point on a computer screen. Once fixated, the screen would change to show an expression for three-seconds followed by an answer screen. The answer screen would include written directions to choose the emotion just seen along with all possible choices for this study (i.e., happy, sad, angry, afraid, or neutral). There would be no time limit to respond. The participant would vocalize their answer, which would be recorded by the experimenter. After answering, the screen would proceed to the fixation target to mark the start of a new item. Three testing blocks were planned, each testing a specific modality. The eye-tracking tasks were estimated to take 15 minutes. See Figure 1 for an example of the eye-tracking task.

Figure 1

Eye-tracking task example with fixation screen, body-only stimulus, and answer screen



Eye-tracking Stimuli. Body stimuli for this study were to be taken from the body expressive action stimulus test (BEAST), which is a validated set of static, grey scale images showing actors' whole bodies (i.e., body and head) with blurred faces, performing emotional (e.g., happy, sad), neutral, or instrumental bodily (e.g., brushing teeth, combing hair) expressions (de Gelder & Van den Stock, 2011). We planned to use 20 images each of happy, sad, angry, fearful, and neutral bodies in the body-only condition. The BEAST set contains more female than male actors, which led to using seven images of male actors and 13 images of female actors.

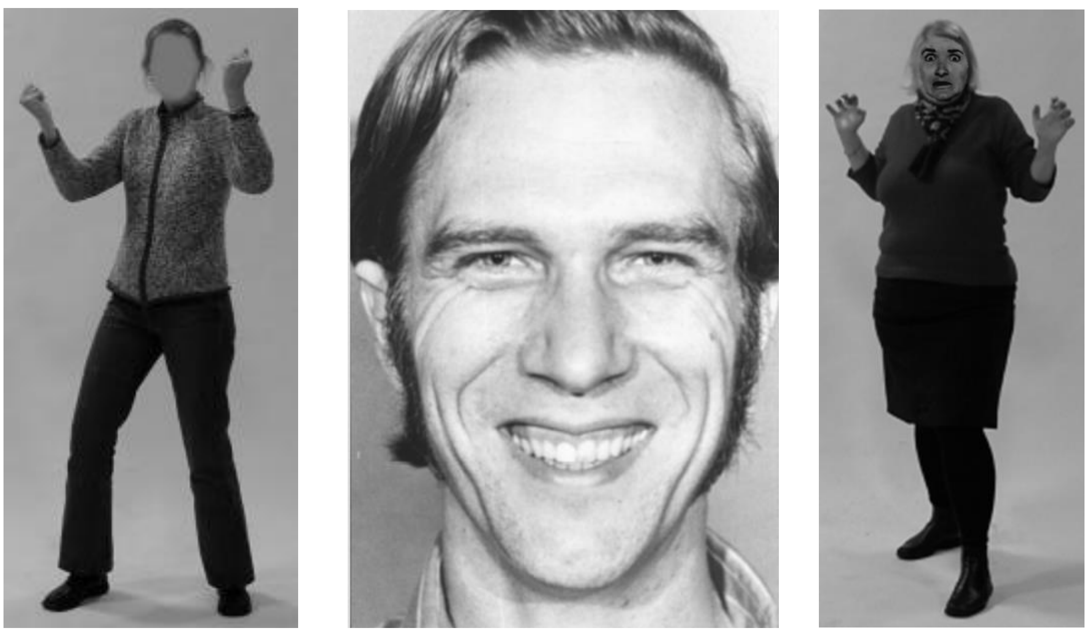
Facial stimuli were obtained from the Ekman pictures of facial affect (Ekman & Friesen, 1976) and the NimStim set of facial expressions (Tottenham et al., 2009). The final face-only task stimuli included seven male images and 13 female images from a mix of the two stimuli sets: anger (Ekman: two male, four female; Tottenham: five male, nine female), happiness (Ekman: two male, four female; Tottenham: five male, nine female), sadness (Ekman: two male, four female; Tottenham: five male, nine female), fear (Ekman: two male, three female; Tottenham: five male, ten female), and neutral (Ekman: two male, three female; Tottenham: five male, ten female).

Stimuli for the face-body task were created by combining congruent faces and bodies from each stimuli set. Previously, this design has been to create stimuli in TD and ASD literature (e.g., Aviezer et al., 2008, 2012; Brewer et al., 2017; Mondloch, 2012; Van den Stock et al., 2007). Again, there will be 20 images of each expression, split between seven male and 13 female actors. Unused body stimuli form the body-only task were combined with Tottenham and Ekman faces to create stimuli for each emotion:

anger (Ekman: two male, three female; Tottenham: five male, ten female), happiness (Ekman: two male, three female; Tottenham: five male, ten female), sadness (Ekman: two male, three female; Tottenham: five male, ten female), fear (Ekman: two male, four female; Tottenham: five male, nine female), and neutral (Ekman: two male, four female; Tottenham: five male, nine female). See Figure 2 for an example of the three types of stimuli.

Figure 2

Examples of body-only, face-only, and face-body stimuli



Areas of Interest. To facilitate examination of eye gaze behavior across modalities and emotions, each stimulus would be divided into distinct areas of interest (AOIs). For each body-only expression, AOIs were to be created by segmenting and tracing major body areas using the AOI tool creator native to SR Eyelink software (SR

Research Ltd., Ontario, Canada) that was to be used in the originally planned study. Resulting areas would include hands, arms, torso, legs, feet, head, neck, and off-body. Face AOIs were to be created by fitting oval-shaped and freely drawn AOIs around the mouth, eye, nose region, whole face, hair, neck, and off-face. This would allow for examination of eye gaze behavior towards these specific, core face regions, as well as non-core face regions as well. Face-body compound AOIs were to be created in the same respective manner for each stimulus. AOIs for the bodily regions of compound stimuli would be drawn in the same fashion as the body-only stimuli and likewise for the facial regions. The entire experiment should take approximately 10 minutes.

Eye Gaze Measures. During the eye-tracking tasks, participants' eye movements were to be recorded in order to collect fixation data including dwell time (i.e., the sum of fixation durations within a specific AOI) and fixation count (i.e., total number of fixations within an AOI; Holmqvist et al., 2011; Rayner, 1998; Schall et al., 2014). Fixations refer to moments when the eyes stop moving and remain relatively stable upon a visual stimulus before moving again Fixations generally last 200 – 300 milliseconds and are thought to relate to the cognitive processing of whatever is fixated upon (Holmqvist et al., 2011; Rayner, 1998). Moreover, with some exceptions, fixation duration is positively associated with the effort and depth of cognitive processing, suggesting that longer fixations reflect deeper processing. Fixation count can reflect which areas receive visual attention, while a higher number of fixations within an AOI may represent confusion (Holmqvist et al., 2011; Schall et al., 2014).

Eye-tracking Apparatus. Eye-movement data were to be collected using SR Research EyeLink 1000 Plus system (SR Research Ltd., Ontario, Canada) with a sampling rate of 500 Hz from the right eye. The EyeLink 1000 Plus has an accuracy to within 0.5º and resolution within 0.01º. We planned to deliver the task from an adjoining room via a Dell computer with a monitor with a resolution of 1920 x 1080 pixels. The eye-tracker and task were to be controlled by a second experimenter from a Dell desktop computer.

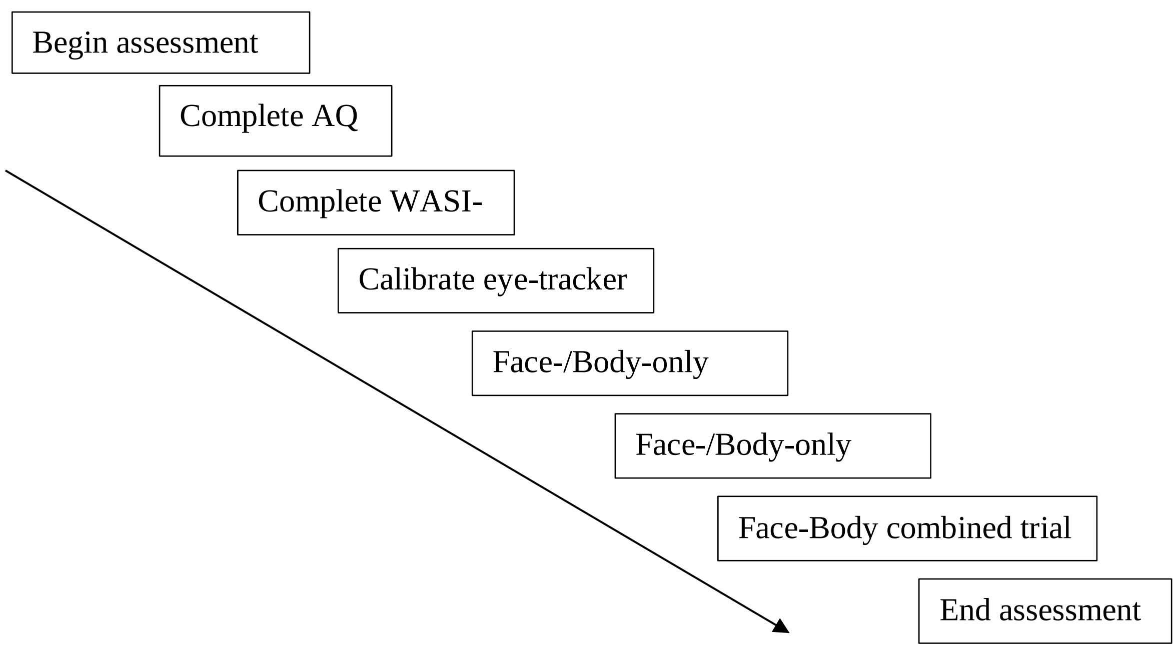
Procedure

All potential participants were to be screened via telephone or email to determine if they qualified for the study. Potential participants were to be asked if they have a current or previous diagnosis of ASD by a licensed psychologist or medical doctor or if they have previously qualified for special education services under the autism category. Additionally, all potential participants were to be asked if they can read and write, sit still for at least 15 minutes, and have been diagnosed with or suspected of meeting criteria for intellectual disability (ID). Qualifying participants will be invited to take part in the study.

After arriving at the testing area, participants would have completed all measures (i.e., AQ, WASI-II, SREIT, SRS-2). Following this, participants would be seated at a table where a chin rest was to be adjusted to comfortably support and constrain their head movements during the task. Next, a 13-point calibration would occur. Once calibrated, the emotion recognition tasks would begin. The face-body task was planned to always follow the face- and body-only tasks, which would be counterbalanced. This choice was made to protect against any possible practice effects. A chart showing the order of tasks can be seen in Figure 3. While different stimuli would be used during the face-body and other recognition tasks, it is possible that participants would be able to correctly label a face-or body-only expression based on information from the compound stimuli. To put this another way, a participant may find a fearful face alone difficult to label but remember a similar expression accompanying a more diagnostic bodily expression if allowed to view the face-body task first. The total session time should take approximately one and a quarter hours.

Figure 3

Order of tasks during assessment



Analysis

To compare differences in recognition accuracy and eye gaze behavior, a 2 (group) x 5 (emotion) x 3 (modality) mixed model analysis of variance (ANOVA) was planned with group as the between-subject variable and modality and emotion as within-subject variables. Proportion of correctly recognized emotional expressions will act as the dependent variable.

To compare eye gaze behavior between ASD and TD groups, three mixed model ANOVAs were to be performed across modalities. For each ANOVA, group was planned as the between-subject variable and AOI and emotion as within-subject variables. Only the number of levels within the AOI factor will change for each ANOVA. Specifically, there were eight AOI levels for the body-only condition (i.e., hands, arms, torso, legs, feet, head, neck, and off-body), seven for the face-only condition (i.e., eyes, mouth, nose, non-core face areas, hair, neck, and off-face), and 12 for the compound face-body condition (i.e., arms, legs, hands, feet, torso, eyes, mouth, nose, non-core face, hair, neck, and off-person).

To determine which areas were most diagnostic for each emotion in the body-only and face-body compound, a series of multiple regression analyses were to be performed with AOI dwell as the predictor and accuracy as the outcome variable.

Pilot Study

Participants

The pilot study was part of larger study examining the relationship between emotion recognition, emotion regulation, social-emotional functioning, and early literacy intervention. Forty-three children originally participated in all pilot study activities; however, two participants were excluded from the final analysis due to invalid eye-tracking calibration and collection, leaving 41 participants. Eye-tracking data was available for all remaining 41 participants. This was not the case for the social-emotional functioning measures, in which data from 37-38 participants were available depending on the measure (discussed more below), and for two demographic variables (Race/Ethnicity, Language Spoken in the Home), in which data from 40 participants were available. Available demographic information for the final 41 participants can be found in Table 2 in Appendix B.

Measures and Instruments

Children's Social and Emotional Measurement Tool. This measurement tool (Child Trends, 2014) provides both a 12-question teacher survey and 14-question self-report student. All questions are answered on a Likert-type scale based on how often a behavior occurs (teacher survey), from 1 (none of the time) to 4 (all of the time), or how much the behavior resembles the rater (student survey, from 1 (not at all like me) to 4 (a lot like me). The teacher survey includes subscales measuring self-control (e.g., regulating and control emotions, behaviors, attention), persistence (e.g., continuing a task voluntarily despite challenges), and social competence (e.g., understanding others' perspectives, cooperation, behaving within social norms). The self-report survey includes subscales for self-control and persistence, as well as mastery orientation (e.g., working and learning due to internal motivation) and academic self-efficacy (i.e., belief in one's own ability to perform well academically). Higher scores are indicative of better social-emotional functioning. This tool was originally intended to be used by teachers and their students in kindergarten through fifth grade. In our study, parents completed the teacher ratings. Internal consistency measures for subscales range from 0.65 to 0.97.

Child Behavior Checklist. The Child Behavior Checklist (CBCL; Achenbach & Rescorla, 2001) is a widely used, parent-rated broadband measure of problematic social, emotional, and behavioral symptoms in children. For this study, the 6-18-year-old version was used. The CBCL comprises a background and demographic section, in which parents can write in information about their child (e.g., school grades, hobbies, illnesses) and a problem rating scale section. There are 113 items in the problem rating scale section, which are answered term of how true the statement in each item describes the child. Ratings range from 0 (not true) to 2 (very true). Sample items include: "Acts too young for his/her age", "Too fearful or anxious", "There is little he/she enjoys". Items correspond to indices of internalizing and externalizing symptoms and produce several subscales that were explored in this study. These include: withdrawal, somatic complaints, anxiety/depression, social problems, rule breaking behavior, and aggressive behavior. This measure has high test-retest reliability, ranging from 0.80 to 0.94.

Eye-tracking Tasks. Participants completed similar emotion recognition tasks as in the originally planned study. In the pilot study, participants completed two, forced-choice emotion recognition labelling tasks instead of the three in the original study. Here, the body-only and face-only tasks were completed. Additionally, in the pilot study, the emotional expression stimuli were shown for seven seconds, rather than the three in the original study. The tasks were the same in this as in the original study except for these differences.

Eye-tracking Stimuli. Body stimuli for this study were the same as intended for the originally planned study (i.e., angry, happy, sad, fearful, neutral expressions taken from de Gelder & Van den Stock, 2011), with one major difference. In the current study, the whole head was either cropped or blurred, while in the originally planned study, heads were present while facial features alone were blurred. The number of stimuli also differed, as only four images each of happy, sad, angry, fearful, and neutral expressions were used in the body-only condition split evenly between two male and two female models, and only two images of each facial expression split between a male and female actor were used form the Ekman & Friesen (1976) stimuli set. Examples of eye-tracking stimuli can be seen in Figure 4.

Figure 4.

Example of fearful body and angry face stimuli

Areas of Interest. To facilitate examination of eye gaze behavior across emotions in the bodily expressions, each emotional figure was divided into distinct areas of interest (AOIs). This was the same process as previously intended with a one difference. First, there was no head in the current body-only stimuli, resulting in only seven AOIs (hands, arms, legs, feet, torso, neck, and off-body) after treating the left and right hands, arms, legs, and feet as one AOI each. Using the freehand AOI creation tool native to the SR system, AOI boundaries were drawn around each body AOI while giving approximately a 0.5º buffer where possible to account for measurement error. In instances where two AOIs rested on or right next to each other (e.g., hand resting on sides of legs), no buffer was provided. When the necessary space between two AOIs to give a full 0.5º buffer was unavailable (e.g., between expanded arms and the torso), an attempts was made to split the difference as best as possible. A similar procedure was used for faces, which required splitting the difference more often. It is also important to note that while each emotion recognition trial lasted for seven seconds, data was only used from the first three seconds of each trial, consistent with the originally planned study.

Procedure

As the pilot study was part of a larger study, participants in the pilot study completed a different series of measures and tasks during their lab visit than in the originally planned study (e.g., reading fluency). Upon arriving, participants' parents went through the informed consent process before exiting and waiting immediately outside the lab in a designated waiting area where they filled out all parent-rating scales. Participants completed a vision screener to ensure they could accurately see printed information throughout the testing sessions. Next, lab personnel directly assessed participants' basic literacy skills and receptive vocabulary, followed by participants completing all self-report measures. A brief break was provided followed by a computer-based go/no-go task during which EEG measurements were recorded. Another break was provided followed by the eye-tracking tasks in the pilot study. Setup for the eye-tracking study was similar except participants completed a 9-point rather than 13-calibration.

Planned Analysis

All data was analyzed using SPSS Version 27. To explore FER and BER performance within each modality along with possible age and sex effects, two separate 5 (Emotion) x 5 (Age Group) x 2 (Sex) mixed measures analysis of variance (ANOVA) operations was carried out. In these, Emotion was the within-subjects factor, while Sex and Age Group were between subject factors. Next, a 5 (Emotion) x 2 (Sex) x 5 (Age Group) x 2 (Modality) mixed measures ANOVA was used to compare emotion recognition across modalities, as well as any age or Sex effects. Again, Emotion was a within-subjects factor as was Modality, while Sex and Age Group were between subject factors.

A series of mixed measure ANOVAs was done to analyze dwell time and fixation count within faces and bodies. In each ANOVA, Emotion and AOI were entered as within-subjects factors, and Sex and Age Group acted as between subject factors, resulting in four, 5 (Emotion) x 7 (AOI) x 2 (Sex) x 5 (Age Group) ANOVAs. Greenhouse-Geisser or Huyn-Feldt adjustments were reported when violations of sphericity assumptions occurred.

Significant main effects of factors and interactions among factors were further explored with post hoc comparisons based on the estimated marginal means. All comparisons were adjusted for multiple comparisons using Bonferroni adjustment.

To explore the relationship between eye gaze and emotion recognition accuracy, correlations were performed next. The percentage of correctly recognized expressions for emotion category was correlated with eye gaze measures for the corresponding AOIs (e.g., percentage of correctly recognized happy expressions correlated with AOI data from happy expressions). Correlations were performed across faces and bodies and for both dwell time and fixation count.

Lastly, another correlational analysis was performed to explore the association between emotion recognition and social-emotional functioning. Emotion recognition accuracy for each face and body emotion category, as well as overall face and body accuracy (i.e., overall proportion of correctly recognized bodies and faces across all emotions), were entered into correlations with raw scores from the scales produced by the CBCL and Children's Social and Emotional Measurement Tool.

CHAPTER IV

RESULTS

Accuracy Comparisons

Accuracy Comparison Within Bodies

To examine any recognition differences within bodily expressions of emotion along with any sex or age effects, a 5 (Emotion) x 5 (Age Group) x 2 (Sex) mixed methods ANOVA was performed. Means for participants' BER performance across emotions broken down by sex and age groups can be found in Table 3 in Appendix B.

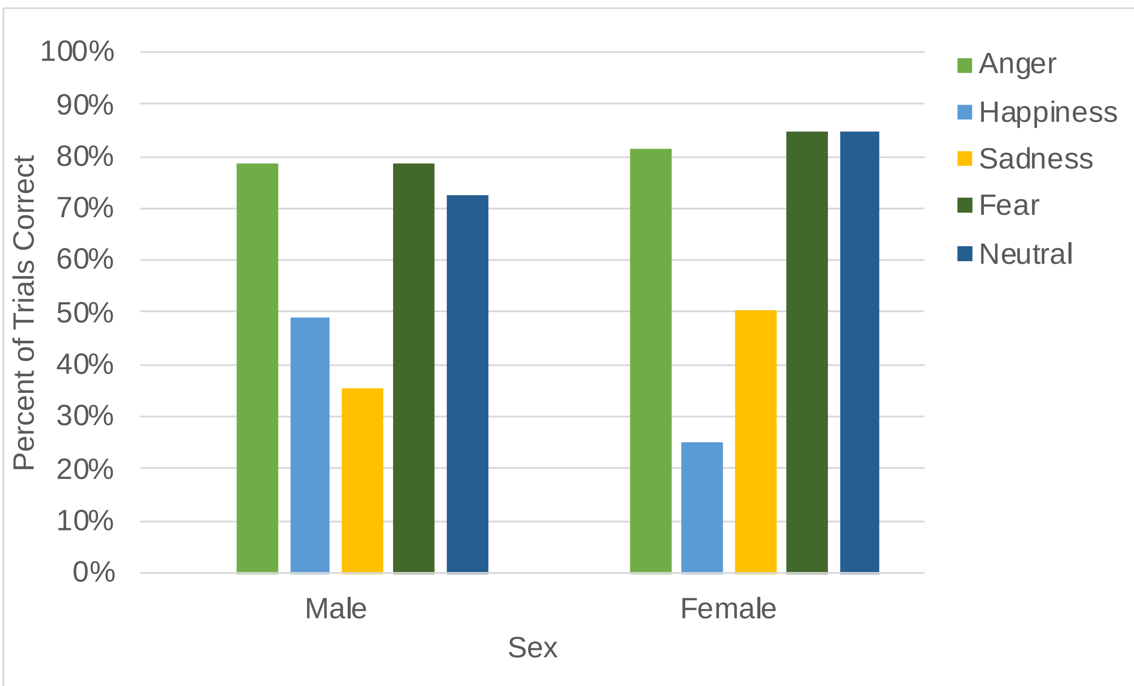
Results indicated a significant, within-subject effect for Emotion ($F(4, 124) = 22.64$, $p < .001$, $\eta_p^2 = 0.42$) and a significant Emotion x Sex interaction ($F(4, 124) = 2.83$, $p = .03$, $\eta_p^2 = 0.08$). No other significant main effects or interactions were found. Full results of the ANOVA can be found in Table 4 in Appendix B.

Post hoc pairwise comparisons of the Emotion x Sex interaction indicated several significant BER performances across emotions within each sex (for a visual see Figure 5). Specifically, male participants showed a recognition accuracy pattern of angry > happy, sad (all *p's* < 0.05); fear > happy, sad (all *p's* < 0.05); and neutral > sad ($p < .01$). Females showed a pattern of angry > happy ($p < 0.001$); fear > happy, sad (all *p's* < 0.05); and neutral > happy, sad (all *p's* < 0.05). Post hoc pairwise comparisons comparing recognition accuracy within each emotion showed no significant sex differences, although there was a trend for better male than female recognition of happiness ($p = .06$).

In all, findings support the hypothesis that participants would recognize some bodily expressions of emotion better than others. While these findings partially support the hypothesis for sex differences in BER, no female advantage appeared and, in fact, trended in the opposite direction. The prediction of accuracy differences across ages was not supported.

Figure 5

Mean percentage of trials recognized correctly for each bodily emotion expression within male and female groups



Accuracy Comparison Within Faces

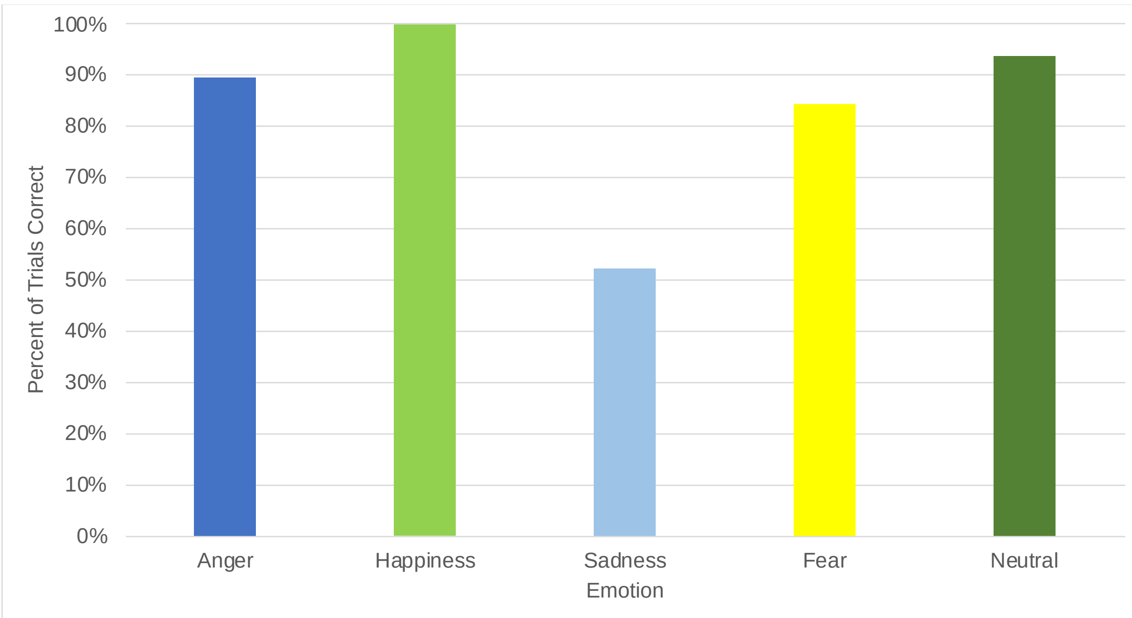
To examine any recognition differences within facial expressions of emotion, a 5 (Emotion) x 5 (Age Group) x 2 (Sex) mixed methods ANOVA was performed. Means for participants' FER performance can be found in Table 5 in Appendix B.

Results indicated a significant within-subject effect for Emotion ($F(2.50, 77.36) = 24.41$, $p < 0.001$, $\eta_p^2 = 0.44$) and a significant between subject effect of Sex ($F(1, 31) = 4.99$, $p = .03$). Emotion was Greenhouse-Geisser corrected due to sphericity violation (χ^2 (9) = 46.80, $p < 0.001$, $\varepsilon = 0.62$). No Age Group or interaction effects were found. Full results of the ANOVA can be found in Table 6 in Appendix B. Post hoc pairwise comparisons of the main effect of Emotion indicated a recognition pattern of happiness > all other emotions and anger, fear, neutral > sadness (all *p*'s < .05; see Figure 6). Sex effects showed better overall female than male FER performance ($p = .03$).

Findings support the hypothesis that participants would better recognize some facial expressions of emotion than others. As predicted, happiness was recognized best. Although not a specific prediction, sadness was the least recognized, which was suprising. In addition, a female advantage for FER was found as predicted but no age differences emerged.

Figure 6.

Mean percentage of trials recognized correctly for each facial emotion expression across all participants



Accuracy Comparison Across Modalities

To examine any emotion recognition differences across modalities, a 5 (Emotion) x 2 (Modality) x 5 (Age Group) x 2 (Sex) mixed methods ANOVA was performed.

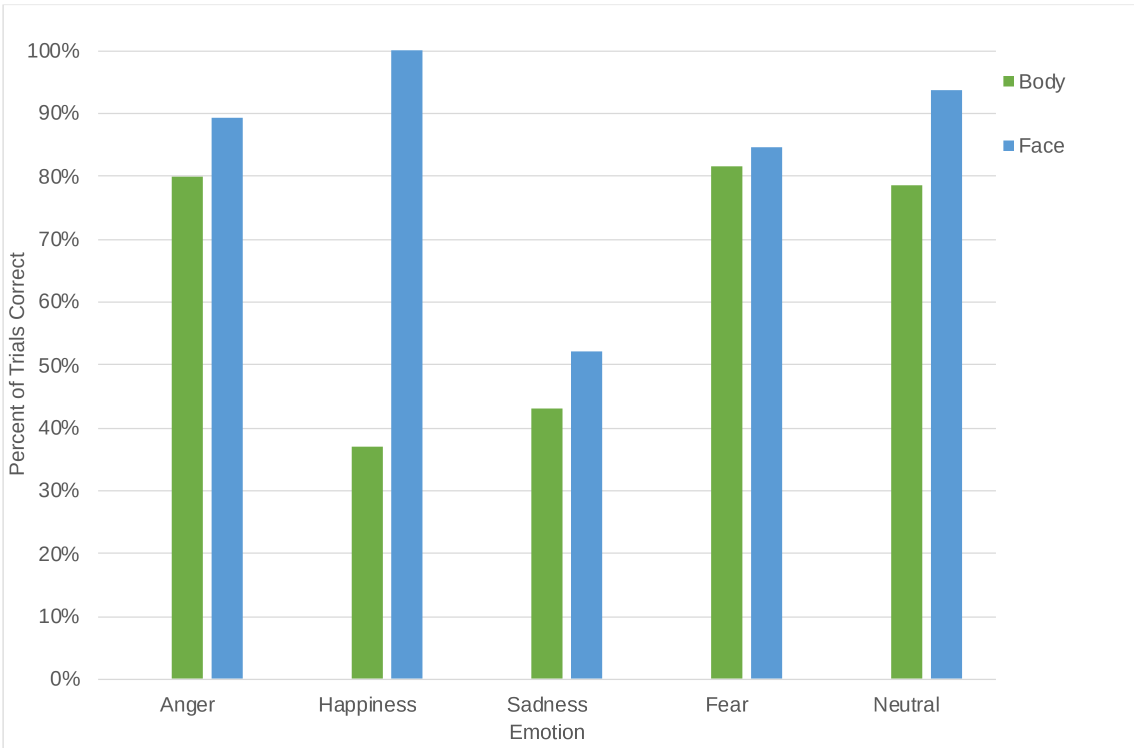
Results showed main effects for Emotion ($F(4, 124) = 28.40$, $p < .001$, $\eta_p^2 = 0.48$) and Modality ($F(1, 31) = 34.90$, $p < .001$, $\eta_p^2 = 0.53$), as well as a significant Emotion x Modality ($F(2.99, 92.81) = 17.68$, $p < .001$, $\eta_p^2 = 0.36$) and Emotion x Sex ($F(4, 124) = 2.57$, $p = .04$, $\eta_p^2 = .08$) interactions. Due to sphericity violations for the effect of Emotion (χ^2 (9) = 16.96, $p = .05$) and for the Emotion x Modality interaction (χ^2 (9) = 17.40, $p = .04$), Huyn-Feldt ($\varepsilon = 1.00$) and Greenhouse-Geisser ($\varepsilon = 0.748$) adjustments were applied, respectively. No other main or interaction effects were found. Full ANOVA results can be found in Table 7 in Appendix B.

Post hoc pairwise comparisons of the Emotion x Modality interaction indicated better recognition of happy ($p < .001$) and neutral ($p = .001$) emotions from the face compared to bodies (see Figure 7). The Emotion x Sex interaction showed a recognition pattern of anger, happy, fear, neutral > sad for males, while females showed a pattern of anger, fear, neutral > happy, sad. Examining sex differences within each emotion showed a female > male effect for neutral ($p = .009$) and a trend for male > female accuracy for happiness ($p = .06$)

Results support the hypothesis that participants would better recognize some emotions from the face compared to the body. There is also support for hypothesized sex differences, including better female performance for some emotions. Again, hypothesized age effects were not supported.

Figure 7.

Differences in recognition performance of each emotion across modalities



Eye Gaze Comparisons

Dwell Time Comparison in Bodies

To examine dwell time differences across body AOIs during the BER task, a 5 (Emotion) x 7 (AOI) x 5 (Age Group) x 2 (Sex) mixed methods ANOVA was performed. Mean dwell times for each AOI are reported by emotion in Tables 8 - 12 in Appendix B.

Results indicated significant main effects for Emotion ($F(4, 124) = 5.87$, $p < 0.001$, $\eta_p^2 = 0.16$) and AOI ($F(2.90, 89.88) = 140.77$, $p < 0.001$, $\eta_p^2 = 0.82$), as well as a significant Emotion x AOI interaction ($F(9.61, 297.79) = 23.47$, $p < 0.001$, $\eta_p^2 = 0.43$).

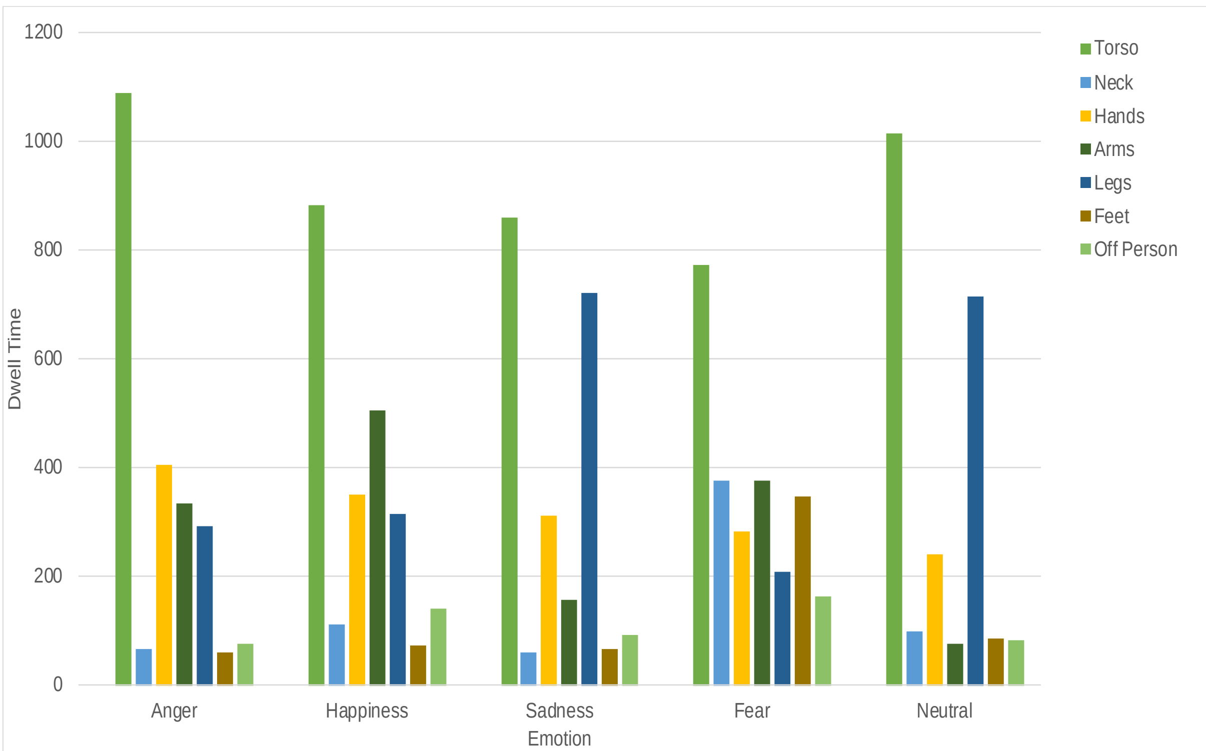
Greenhouse-Geisser adjustments were reported due to sphericity violations in the main effect of AOI (χ^2 (20) = 110.84, $p < 0.001$, $\varepsilon = 0.48$) and in the Emotion x AOI interaction ($\chi^2(299) = 540.82$, $p < 0.001$, $\varepsilon = 0.40$). No other significant main or interaction effects emerged. Full results of the ANOVA can be found in Table 13 in Appendix B.

To answer the question of whether or not participants in the pilot study spent more time fixating upon the upper body areas, post hoc pairwise comparisons for the Emotion x AOI interaction were done. For angry body expressions, pairwise comparison results indicated a dwell time pattern of longer overall fixation time for the torso > all other AOIs; hands > neck, feet, and off-body; arms > neck, feet, off-body; legs > neck, feet, off-body (all *p*'s < .05). Results for happy expressions indicated a similar pattern of torso > all other AOIs; hands > neck, feet, and off-body; arms > neck, legs, feet, off-body; legs > neck, feet, off-body; and off-body > feet (all *p*'s < .05). In sad bodies, dwell time differences showed torso > neck, hands, arms, feet, off-body; hands > neck, arms, feet, off-body; legs > neck, hands, arms, feet, off-body (all *p*'s < .05). In fearful expressions, participants fixated longer on the torso > all other AOIs; neck > off-body; hands > off-body; arms > legs, off-body; feet > off-body (all *p*'s < 0.05). Lastly, pairwise comparison within neutral expressions, indicated a pattern of torso > neck, hands, arms, feet, off-body; hands > arms, feet, off-body; legs > neck, hands, arms, feet, off-body (all *p*'s < 0.05).

Overall, these results are largely consistent with the hypothesis that participants would fixate longer on upper body areas; however, inconsistencies emerged showing longer dwell time for legs than some upper body areas in sad and neutral expressions. Pairwise comparison results are visually represented in Figure 8. Visual representations in the form of Heat Maps, which reflect overall dwell time in areas across all participants, can be found for each emotion in Figure 9.

Figure 8.

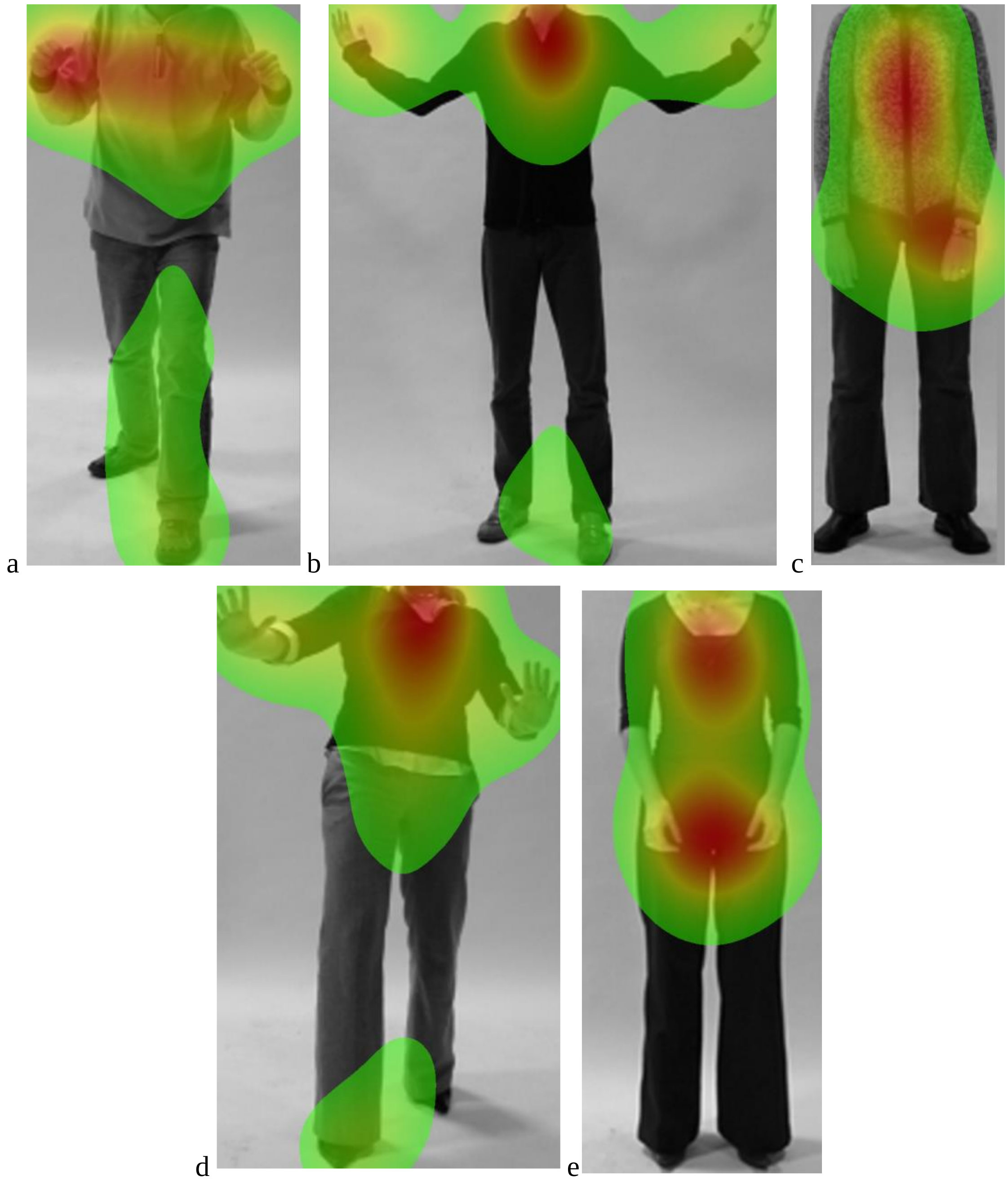
Differences in dwell times across AOIs while viewing of bodily expressions of emotion



Note. AOI = Area of Interest

Figure 9.

Visual representations of overall dwell times for body regions across all participants while viewing bodily expressions of: (a) anger, (b) happiness, (c) sadness, (d) fear, and (e) neutral



Note. Longer overall fixation time is represented in red. Shorter overall fixation time is represented in green.

Dwell Time Comparison in Faces

To assess for dwell time differences across face AOIs during the FER task, a 5 (Emotion) x 7 (AOI) x 5 (Age Group) x 2 (Sex) mixed methods ANOVA was performed. Mean dwell times for each AOI are reported by emotion in Tables 14 - 18 in Appendix B.

Results indicated a significant main effect of AOI ($F(1.69, 52.34) = 69.87$, $p < 0.001$, $\eta_p^2 = 0.69$), as well as significant Emotion x AOI ($F(8.97, 278.18) = 7.25$, $p < 0.001$, $\eta_p^2 = 0.19$) and Emotion x Age Group ($F(16, 124) = 2.52$, $p < 0.001$, $\eta_p^2 = 0.22$) interactions. Greenhouse-Geisser adjustments due to violation of sphericity were applied to AOI effects (χ^2 (20) = 310.88, $p < 0.001$, $\varepsilon = 0.28$) and the Emotion x AOI interaction (χ^2 (299) = 907.77, $p < 0.001$, $\varepsilon = 0.37$). No significant effects for age, sex, or other interactions were found. Full ANOVA results can be found in Table 19 in Appendix B.

To answer the question of whether or not participants in the pilot study spent more time fixating upon core diagnostic face areas, results of the post hoc pairwise comparisons for the Emotion x AOI interaction are discussed next and can be seen in Figure 10, showing several differences. For angry expressions, significant dwell time differences showed a pattern of eyes > mouth, non-core face, hair, neck, off-face; nose > hair, neck, off-face; mouth > hair, neck, off-face; and non-core face > hair, neck, off-face (all *p*'s < .05). In happy expressions, a pattern of eyes > non-core face, hair, neck, off-face; nose > non-core face, hair, neck, off-face; mouth > non-core face, hair, neck, off-face; and non-core face > hair, neck, off-face emerged (all *p*'s < .05). Sad expressions showed a pattern of eyes > all other AOIs; nose > hair, neck, off-face;

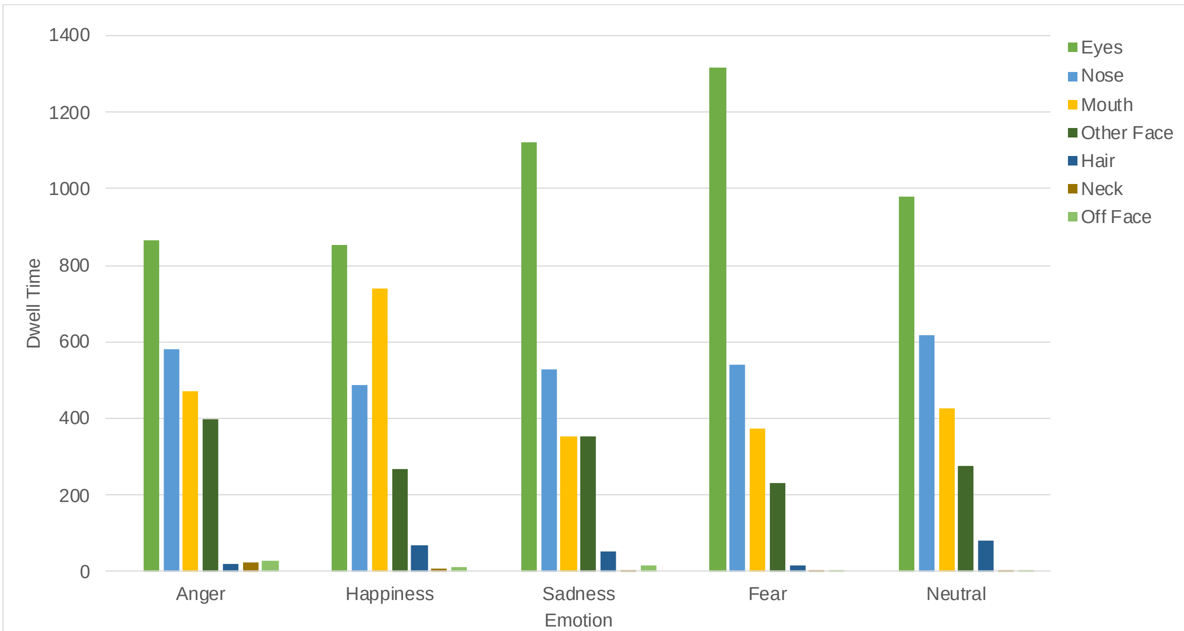
mouth > hair, neck, off-face; and non-core face > hair, neck, off-face (all *p*'s < .05). For fear, significant dwell time differences showed a pattern of eyes > all other AOIs; nose > non-core face, hair, neck, off-face; mouth > hair, neck, off-face; and non-core face > hair, neck, off-face (all *p*'s < .05). Lastly, for neutral expressions significant dwell time differences showed a pattern of eyes > mouth, non-core face, hair, neck, off-face; nose > non-core face, hair, neck, off-face; mouth > hair, neck, off-face; and non-core face > hair, neck, off-face (all *p*'s < .05). Heat Maps showing examples of participants' dwell time behavior across emotions can be seen in Figure 11.

Next, to answer the question of whether age affected FER accuracy, post hoc pairwise comparisons of the Emotion x Age Group interaction are now discussed. The only significant comparison showed longer overall dwell time in seven-year-old participants compared to 10-year-old participants ($p = 0.03$). No other pairwise comparisons resulted in significant differences for the Emotion x Age Group interaction.

In all, deeper examination of the Emotion x AOI interaction supported the hypothesis that participants in the pilot study spent more time fixating on the core face areas (i.e., eyes, nose, mouth). Conversely, the Emotion x Age Group post hoc comparisons only partially supported the hypothesis that age would affect FER performance.

Figure 10

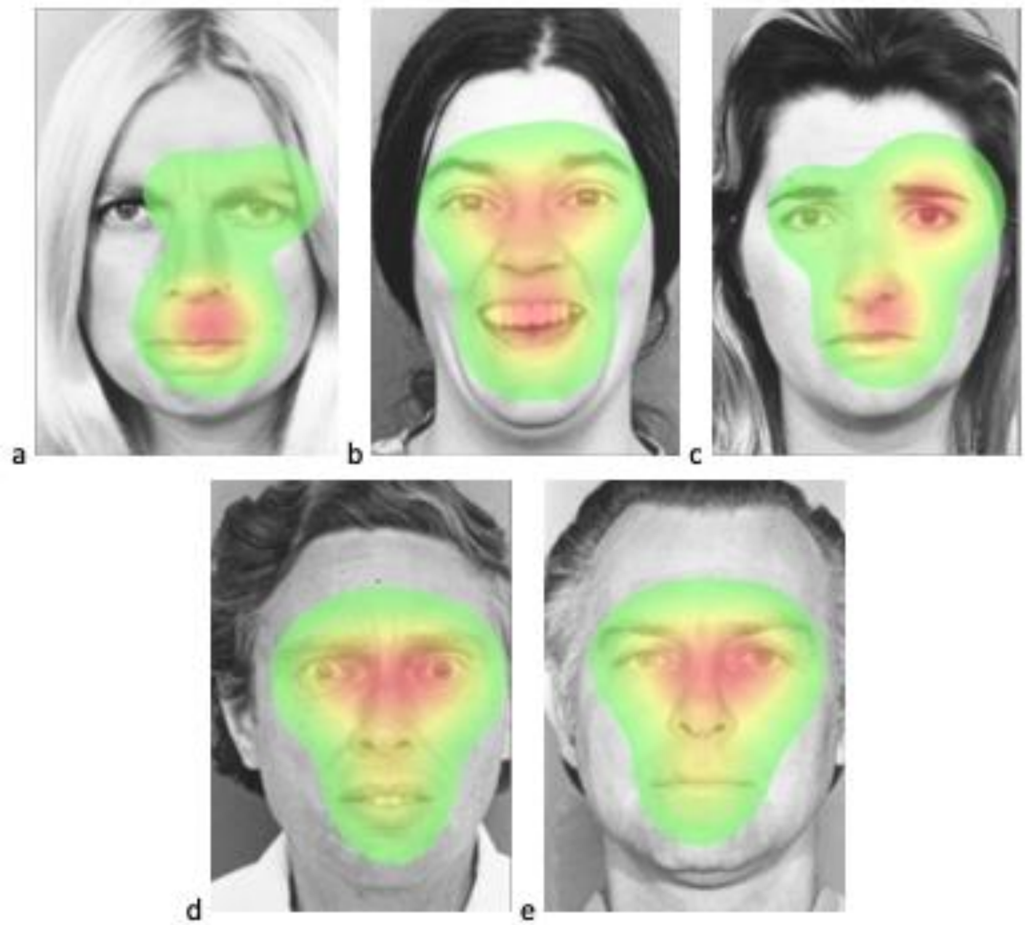
Differences in dwell times across AOIs while viewing of facial expressions of emotion



Note. AOI = Area of Interest

Figure 11

Visual representations of overall dwell times for face regions across all participants while viewing facial expressions of: (a) anger, (b) happiness, (c) sadness, (d) fear, and (e) neutral



Note. Longer overall fixation time is represented in red. Shorter overall fixation time is represented in green

Fixation Count Comparison in Bodies

To examine fixation count differences across body AOIs during the BER task, a 5 (Emotion) x 7 (AOI) x 5 (Age Group) x 2 (Sex) mixed methods ANOVA was performed. Mean number of fixations for each AOI are reported by emotion in Tables 20 - 24 in Appendix B.

Results indicated main effects for Emotion ($F(3.17, 114.20) = 7.68$, $p < 0.001$, $\eta_p^2 = 0.18$) and AOI ($F(3.23, 116.32) = 214.41$, $p < 0.001$, $\eta_p^2 = 0.86$). There was also a significant Emotion x AOI interaction ($F(10.05, 361.71) = 37.50$, $p < 0.001$, $\eta_p^2 = 0.51$). Greenhouse-Geisser adjustments were reported due to a sphericity violation in the main effect of Emotion ($\chi^2(9) = 44.84$, $p < .001$, $\varepsilon = 0.68$) and the Emotion x AOI interaction ($\chi^2(299) = 561.56$, $p < .001$, $\varepsilon = 0.33$). No significant effects for Age Group, Sex, or other interactions emerged. Full results of the ANOVA can be seen in Table 25.

To answer the question of whether or not participants in the pilot study made more fixations to upper body areas, results of the post hoc pairwise comparisons for the Emotion x AOI interaction are discussed next. Several significant differences emerged among dwell time for specific AOIs across emotions, which are represented in Figure 12.

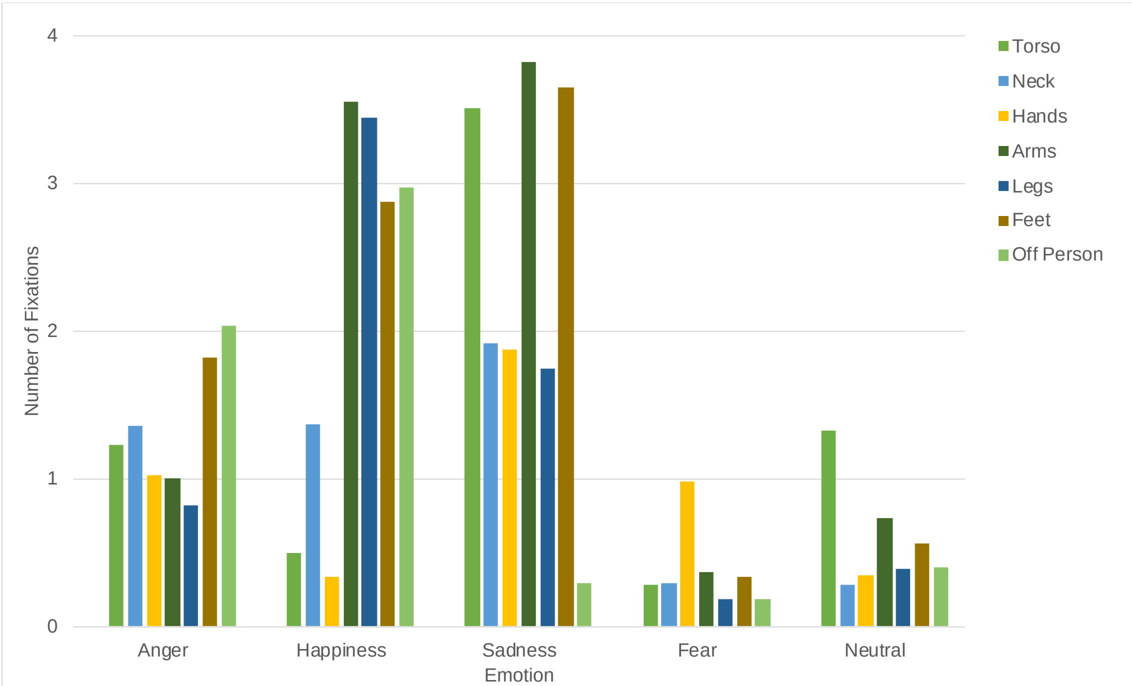
In angry expressions, results indicated a pattern of more fixations on the torso > all other AOIs; hands > neck, feet, off-body; arms > neck, feet, off-body; legs > hands, neck, feet, off-body (all *p*'s < .05). For happy expressions, there was a pattern of torso > all other AOIs; hands > neck, feet, and off-body; arms > hands, neck, feet, off-body; legs > neck, feet, off-body; and off-body > neck, feet (all *p*'s < .05). When viewing sad expressions, participants made more fixations on the torso > neck, hands, arms, feet, off-body; hands > neck, arms, feet, off-body; legs > neck, hands, arms, feet, off-body (all *p*'s < .05). During recognition of fear, a pattern emerged showing torso > all other AOIs;

neck > hands, feet, off-body; hands > off-body; arms > off-body; feet > off-body (all *p*'s < 0.05). Lastly, for neutral expressions more fixations were made on the torso > neck, hands, arms, feet, off-body; hands > neck, arms, feet, off-body; legs > neck, hands, arms, feet, off-body (all *p*'s < 0.05).

In all, fixation count results for body expressions are largely consistent with the hypothesis that participants would make more fixations on upper body areas, although inconsistencies emerged. Participants made more fixations on the legs than some upper body areas in angry, happy, sad, and neutral expressions. Examples of individual participant's actual gaze behavior (e.g., locations and number of fixations) can be found in Figure 13.

Figure 11

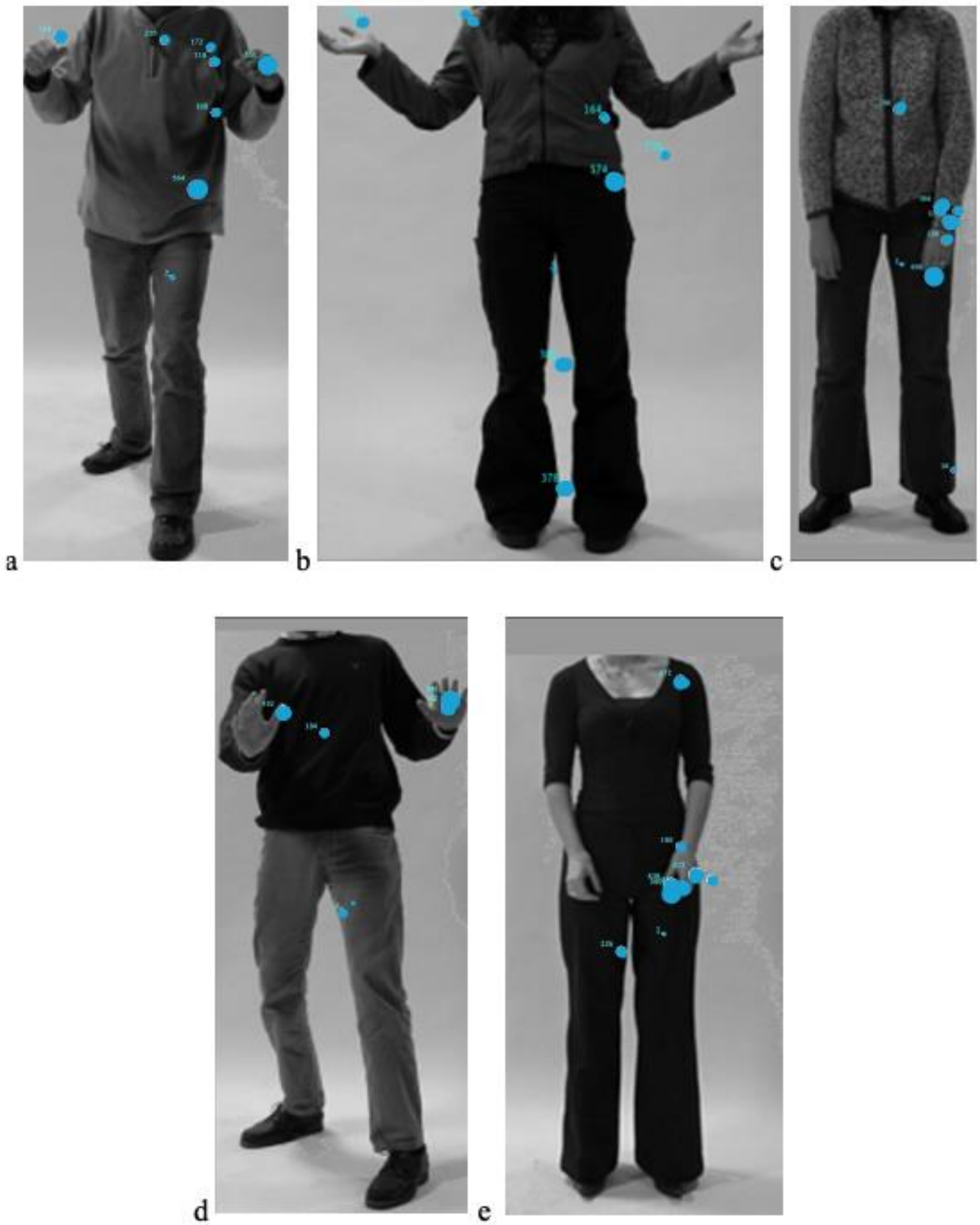
Differences in number of fixations across AOIs while viewing bodily expressions of emotion



Note. AOI = Area of Interest

Figure 12

Examples of individual participant's location and number of fixations for bodily emotion recognition trials of: (a) anger, (b) happiness, (c) sadness, (d) fear, (e) neutral



Note. Dots represent single fixations. Numbers represent length of corresponding fixation. Larger dots represent longer fixations.

Fixation Count in Faces

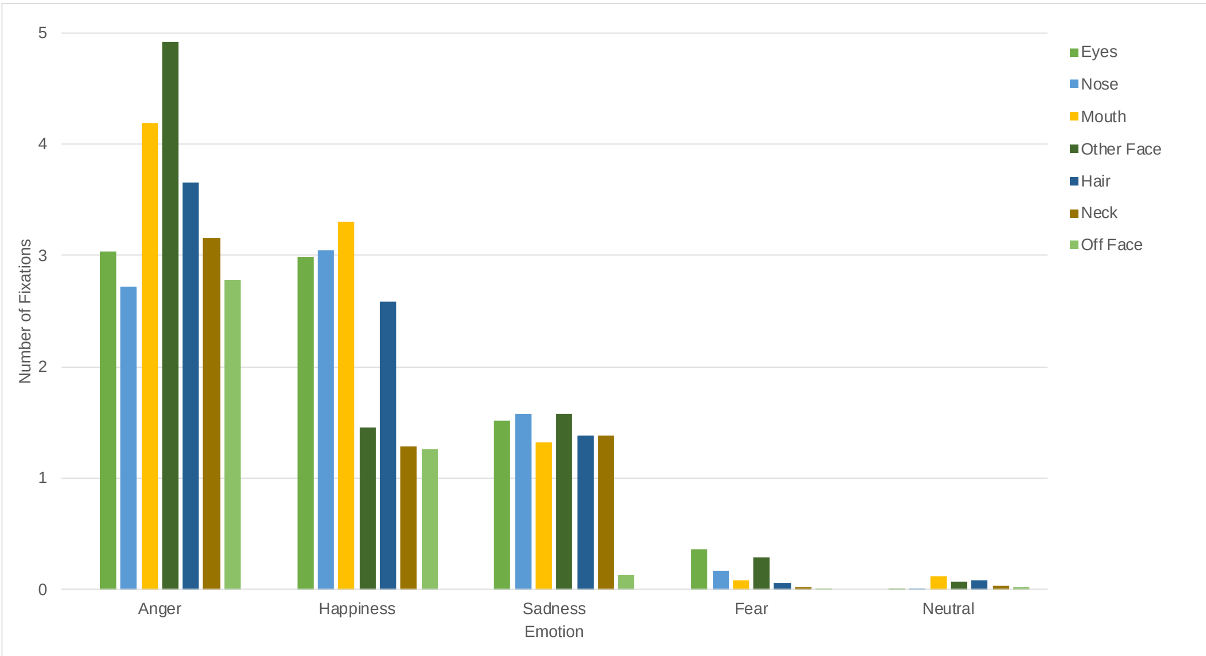
To test for fixation count differences across face AOIs during the FER task, a 5 (Emotion) x 7 (AOI) x 5 (Age Group) x 2 (Sex) mixed methods ANOVA was performed. Mean number of fixations for each AOI are reported by emotion in Tables 26 - 30 in Appendix B.

Results showed main effects of Emotion ($F(1.46, 45.34) = 253.41$, $p < 0.001$, $\eta_p^2 = 0.90$) and AOI $F(3.40, 105) = 16.45$, $p < 0.001$, $\eta_p^2 = 0.35$). There was also a significant Emotion x AOI interaction ($F(7.10, 219.27) = 10.07$, $p < 0.001$, $\eta_p^2 = 0.25$). Greenhouse-Geisser adjustments were reported due to a sphericity violation in the main effects of Emotion ($\chi^2(9) = 139$, $p < .001$, $\varepsilon = 0.37$) and AOI ($\chi^2(20) = 56.49$, $p < .001$, $\varepsilon = 0.57$) and for the Emotion x AOI interaction ($\chi^2(299) = 756$, $p < .001$, $\varepsilon = 0.30$). No significant effects for Age Group, Sex, or other interactions emerged, although the Emotion x Age Group x Sex interaction ($F(5.85, 45.33) = 2.16$, $p = .07$) approached significance. For full ANOVA results see Table 31 in Appendix B.

To investigate the question of whether or not participants in the pilot study spent made more fixations upon core diagnostic face areas, post hoc pairwise comparisons for the Emotion x AOI interaction were carried out. Results of these post hoc comparisons indicated several differences in fixation counts towards specific AOIs across emotions, which can be seen in Figure 14.

Figure 13.

Differences in number of fixations across AOIs while viewing facial expressions of emotion



Note. AOI = Area of Interest

Specifically, results show that in angry expressions, participants made a pattern of more fixations on the eyes > mouth, non-core face, hair, neck, off-face; nose > mouth, non-core face, hair, neck, off-face; mouth > hair, neck, off-face; and non-core face > hair, neck, off-face (all p's < .01). A similar pattern for happy expressions indicated a fixation count pattern of eyes > non-core face, hair, neck, off-face; nose > non-core face, hair, neck, off-face; mouth > non-core face, hair, neck, off-face; non-core face > hair, neck, off-face; and hair > neck, off-face (all p's < .05). In sad expressions, there was a pattern of eyes > mouth, non-core face, hair, neck, off-face; nose > mouth, non-core face, hair, neck, off-face; mouth > hair, neck, off-face; and non-core face > hair, neck, off-face (all *p*'s < .05), while fearful expressions produced a pattern of eyes > all other AOIs; nose > mouth, non-core face, hair, neck, off-face; mouth > hair, neck, off-face; and non-core face > hair, neck, off-face (all *p*'s < .05). Lastly, the pattern for neutral expressions indicated eyes > mouth, non-core face, hair, neck, off-face; nose > mouth, non-core face, hair, neck, off-face; mouth > hair, neck, off-face; and non-core face > hair, neck, off-face (all *p*'s < 0.05).

In all, fixation count results for facial expressions are largely consistent with the hypothesis that participants would make more fixations on core face areas. Examples of participants' actual gaze behavior can be found in Figure 15.

Figure 14

Examples of individual participant's location and number of fixations for bodily emotion recognition trials of: (a) anger, (b) happiness, (c) sadness, (d) fear, (e) neutral

Note. Dots represent single fixations. Numbers represent length of corresponding fixation. Larger dots represent longer fixations.

Relationships between Eye Gaze and Emotion Recognition

To explore the relationship between eye gaze behavior and emotion recognition accuracy, a series of correlations were performed. Given the limited number of significant relationships, correlation tables are not reported. Rather, significant findings between emotion recognition and eye gaze behavior for specific AOIs are reported by modality.

Body AOI Gaze and BER

Results of the correlation between body AOI dwell time and fixation count and BER accuracy indicated a significant negative correlation between dwell time on sad legs and accurate BER for sad expressions ($r(39) = -0.39$, $p = .01$). For fixation count, accurate BER for sadness was positively associated with number of fixations to sad arms ($r(39) = 0.33$, $p = .04$) and sad torso ($r(39) = 0.32$, $p = .04$). Accurate BER for angry expressions was related to number of fixations to the hands in angry expressions ($r(39) = 0.38$, $p = .02$), while neutral BER performance was positively correlated with fixations off-body during neutral expressions ($r(39) = 0.36$, $p = .02$). These results partly answer the research question wondering if there is an association between eye movements during a BER task and accuracy on that task. While relationships are not found for every emotion, they exist.

Face AOI Gaze and FER

In exploring the presence of an association between eye movements across different face AOIs and FER accuracy, correlational results showed a negative relationship between FER performance for neutral face expressions and dwell time on the nose in neutral expressions ($r(39) = -0.35$, $p = .03$). Of note, due to 100% FER performance for happy faces, no correlations were completed due to lack of variability in the data. When examining fixation count, there was a positive correlation between FER for angry faces and fixation count to angry noses ($r(39) = 0.38$, $p = .02$), while FER for sad face expressions was negatively associated with the amount of fixations on sad eyes ($r(39) = -0.31$, $p = .05$) and positively associated with fixations to non-core facial features ($r(39) = 0.38$, $p = .02$). A positive correlation emerged between FER for fear and fixation count to hair in fearful faces ($r(39) = 0.49$, $p = .001$). In contrast to our hypothesis, it appears that FER performance was not related to more and/or longer fixations on core facial features, except for the nose in angry expressions.

Relationship between Emotion Recognition and Social-Emotional Functioning

Lastly, to test for a relationship between emotion recognition performance and social-emotional functioning in children, we performed correlations between FER and BER performance and parent and child ratings from social-emotional measures. Means and SD of ratings on the Children's Social Emotional Measurement Tool and CBCL can be found in Table 32. Again, due to the limited number of significant findings, correlation matrix tables are not included here.

BER and Social-Emotional Functioning

Regarding a possible relationship between BER and social-emotional functioning, results indicated multiple significant correlations. Accurate BER for sad bodies was negatively correlated with child-rated self-control ($r(39) = -0.31$, $p = .047$), and positively correlated with CBCL ratings of social problems ($r(36) = 0.33$, $p = .04$) and sluggish cognitive tempo ($r(36) = 0.36$, $p = .03$). CBCL ratings of anxiety problems were negatively associated with BER for anger expressions ($r(36) = -0.32$, $p = .047$). From this, we conclude that BER performance was related to social-emotional outcomes, but not necessarily in the expected direction. Better recognition of anger from bodies was related to less parent-rated anxiety concerns; however, better recognition of sad bodies was associated with poorer self-control, social functioning, and slower cognitive processing.

FER and Social-Emotional Functioning

In exploring connection between children's FER and social-emotional functioning, results indicated lower anxiety levels associated with better recognition of angry faces expressions ($r(36) = -0.32$, $p = .047$). Similarly, FER for sad expressions was related to lower levels of withdraw-depressive symptoms ($r(36) = -0.36$, $p = .03$) and higher levels of parent-rated social competence ($r(36) = 0.38$, $p = .02$), as was accurate recognition of neutral faces ($r(36) = 0.42$, $p = .009$). Finally, overall FER performance was also associated with higher levels of social competence (. Together, these results lend support to the hypothesis that better FER performance is related to better social-emotional functioning.

CHAPTER V

DISCUSSION AND CONCLUSION

There is a long line of research examining humans' emotion recognition ability; however, the majority has focused on recognizing emotion from facial expressions. Nevertheless, bodies can convey the same emotional signals accurately and effectively, leading to several findings that suggest a fuller understanding of emotion processing generally and recognition specifically is incomplete without the inclusion of bodies (e.g., Atkinson et al., 2004; Aviezer et al., 2012; de Gelder, 2009; de Gelder & van den Stock, 2011). Additionally, among the many characteristics shared between TD bodily and facial emotion processing, the presence of unique core diagnostic regions and associated patterns of visual processing is particularly relevant to both the pilot and originally planned studies. Increased focus on these characteristics, along with advancements in and wider availability of experimental tools such as eye-trackers, has provided new avenues for deeper exploration and understanding of how emotion expressions are perceived in TD and clinical populations, such as ASD (e.g., Pelphrey et al., 2002; Pollux et al., 2019; Schurgin et al., 2014).

There remains, however, a noticeable lack of literature regarding bodily emotion processing relative to faces. This includes studying the visual processing and emotion recognition of emotional bodies, as well as how they emerge during typical development periods and across sex. Furthermore, TD humans are thought to be socially wired (e.g., Chevalier et al., 2012), and our capability for nonverbal emotion recognition has adaptively evolved to influence our social-emotional functioning (Frith & Frith, 2010).

A relationship several researchers have explored in faces (e.g., Izard et al., 2001). Yet, it is possible that fewer studies have explicitly examined the role body emotion processing may play in broader social-emotional functioning relative even to BER performance.

As such, this pilot study sought to expand the current body emotion processing literature by attempting to answer several research questions. These questions related to differences in recognition performance across basic emotions, both within and across bodies and faces, as well as how age and sex may affect performance as seen in the FER literature (e.g., Herba et al., 2006; Montirosso et al., 2009). Further, we examined how children's visual processing for bodily emotional expressions matches up with the available literature (e.g., Coulson, 2004; Pollux et al., 2019) for different ages and sex. We also explored the relationships between eye gaze and emotion recognition accuracy, as well as between BER performance and participants' social-emotional functioning.

Emotion Recognition Performance

Recognition within Modalities

Our first research question focused on which emotions would be best recognized within BER and FER tasks, and how sex and age might affect accuracy outcomes. Focusing on BER first, findings partially supported our hypothesis that participants would recognize some emotions better than others, with angry, fearful, and neutral bodily emotions generally better recognized than happy and sad expressions. For instance, adults in Pollux et al. (2019) recognized anger best, but fear was the hardest to recognize, as was also found in Nelson and Russell (2011). Participants in the pilot study, however, showed relatively high recognition for fearful bodies. Sad and happy expressions were the least recognized in the pilot study, whereas other researchers have found accurate BER for sadness to emerge first (Witkower et al., 2020) followed closely by happiness (Boone & Cunningham, 1998).

While an explanation for the differences between the pilot study and previous findings is not readily apparent, it is possible that the age range of participants in the pilot study (7-11 years) marks a developmental shift in the primacy of sadness to anger. In studies of young children up to eight-years old, Witkower et al. (2020) and Boone and Cunningham (1998) found higher levels of BER accuracy for sadness compared to other emotions tested but this is not the case for adults (Pollux et al., 2019). Ross and colleagues (2012) found that children show a rapid rate of BER improvement through childhood until age eight. Around this age, their improvement rate levels off tremendously, with only slight, protracted improvement expanding into late childhood and adolescence (Ross et al., 2012). Thus, results of the pilot study may reflect a maturation in bodily expression processing, which would make sense from an evolutionary lens. Bodies can relay information from a distance without facial features, a skill that could be more beneficial to perceiving possible negative and dangerous situations (de Gelder et al., 2015; Gu et al., 2013).

In addition, several aspects specific to the stimuli in the pilot study may have contributed to the pattern BER performance in the pilot study. Coulson (2004) found that TD adults' point of view (i.e., frontal, side, or rear view) affected their BER performance for several basic emotional expressions. Participants found anger easiest to decode from the front but hardest from the rear. The opposite pattern was seen for happy expressions, while sad was best viewed from the side. Fear recognition was poorest from behind, while no difference was seen between frontal and side views (Coulson, 2004). Had optimal viewing angles been available, higher levels of happy and sad recognition would have likely emerged, consistent with previous research.

In addition, static stimuli were used in the pilot study. With static stimuli, the specific posturing of bodily emotions is highlighted, while dynamic displays also communicate motion, which may provide additional diagnostic qualities (Dael, 2013; Witkower & Tracy, 2019). In other words, some emotion may be inherently less recognizable from static compared to dynamic stimuli. For instance, dynamic displays likely better communicate the upward, expansive movements associated with happy body expressions relative to a still image. Thus, it stands to reason that participants would recognize a higher proportion of happy trials with motion information present. This may also explain the lack of similarity between our pilot study and some of the previous research that used dynamic stimuli (Boone & Cunningham, 1998; Nelson & Russell, 2011).

Nevertheless, the use of static stimuli may not explain the low recognition performance for sadness, which is characterized by its low motion content. Rather, in an attempt to focus participants' attention on the body specifically in the pilot study, the whole head region, not simply the face, was blurred or cropped from the displays. This may have unintentionally affected performance, as head posturing, even without facial features, may affect BER performance (Witkower & Tracy, 2019). As such, unique diagnostic features may have been missing.

In contrast, results of the FER task indicated significantly better recognition of happiness than any other emotion, as hypothesized. This is not surprising given several past findings of an early bias for happy faces and earlier emergence of FER of happy faces relative to other emotions (Farroni et al., 2007; Herba et al., 2006). Although we made no other specific predictions, it was surprising that participants also recognized fearful, angry, and neutral faces better than sad expressions. Recognition of sad faces has been shown to emerge early in development, often following FER for happy expressions (Cheal & Rutherford, 2011; Durand et al., 2007; Vicari et al., 2000). While not formally examined in the pilot study, errors made during sad face trials may provide some clarity. A cursory review of participants' choices indicated fear and neutral labels were often chosen during incorrect sad trials. It is possible that when presented together in the pilot study, sadness became more ambiguous and was mistaken for one of these other emotions, likely due to overlapping posturing of facial features (e.g., similar mouth shape). Other researchers have shown that children attribute misattribute sad and neutral expressions in ambiguous contexts (Durand et al., 2007).

Age and Sex within Modalities

In addition to examining differential recognition accuracy for certain emotions, age and sex were also hypothesized to affect recognition performance. No age effects were seen during either BER or FER. As already mentioned, it is possible that children in this age range are already past a developmental jump in BER ability (Ross et al., 2012). Had we extended the age range of our sample in both directions, age effects likely would have emerged in line with other findings (Boone & Cunningham, 1998; Ross et al., 2012; Witkower et al., 2020). For FER, the results suggest that all participants showed similarly poor performance for sadness and high accuracy for all other emotions regardless of age. Considering multiple findings highlighting the early development of sad FER, it is unclear why it was low in the pilot. Possibly, a factor related either to the stimuli or the study itself may have inadvertently affected performance.

Conversely, as hypothesized, sex affected results in both tasks. For bodies, both males and females generally showed better recognition of angry, fearful, and neutral expressions compared to happy and sad, although slight variations were seen. The presence of sex effects is largely inconsistent with the limited BER literature (Boone & Cunningham, 1998; Parker et al., 2013; Ross et al., 2012). However, results did not indicate a distinct advantage for one sex over the other, as is often found in the FER literature for females (e.g., Hampson et al., 2006**).** Rather, a somewhat unique pattern emerged wherein sadness was better recognized by females and happiness in males for certain comparisons. Moreover, this pattern possibly reflects a better awareness of negative emotions in females than males. In the pilot FER findings, a clear female advantage emerged, consistent with both our hypothesis and several findings in the FER research base (Lawrence et al., 2015; Wingenbach et al., 2018; Kret & de Gelder, 2012). From an evolutionary perspective, a female emotion recognition advantage may serve to maintain threat awareness, as well as to inform gendered expectations to care for others and maintain social connections (Kret and de Gelder, 2012).

Recognition Across Modalities

The second research question built upon the first, targeting the lack of clear knowledge about whether certain emotions are better recognized in one modality relative to another. Limited direct comparisons in research have suggested poorer BER than FER for certain age groups (Nelson & Russell, 2011), while other researchers have suggested that certain emotions are better recognized from certain modalities in adults (Actis-Grosso et al., 2015; Avezier et al., 2012; Coulson, 2004). Consistent with these findings and our hypothesis, this pilot study showed significantly more accurate recognition of happy and neutral expressions from the face than the body, in line with FER developmental literature.

TD children learn to discriminate neutral from emotional faces within the first year of life (Farroni et al., 2007, LaBarbera et al., 1976). As mentioned above, TD individuals also develop FER for happy expressions first and reach adult-like levels sooner than for other emotions (Cheal & Rutherford, 2011; Durand et al., 2007; Vicari et al., 2000). In turn, this may relate to more experience with happy faces, which are often directed towards children early in development. In light of past and present findings, we conclude that recognizing happy emotions and discriminating the presence or absence of emotion may be better suited to the face than the body when only one modality is available.

Age and Sex Across Modalities

There was also a question of age and sex effects in emotion recognition across modalities. Findings indicated that the FER advantage for happy and neutral expressions was not related to participants' age, similar to BER and FER task results. It appears that TD children's emotion recognition ability for basic emotions of anger, happiness, sadness, fear, and neutral expressions does not significantly change across the ages tested in the pilot study. Durand et al. (2007) reported similar results in their study of FER wherein 9-12-year-old children showed comparable FER for the same emotions used in the pilot study, while seven-year-old children differed from older children and adults for anger and neutral expressions. However, female participants showed better recognition of neutral expressions overall. The ability to discriminate the presence or absence of an emotion may help to prevent the misattribution of emotional states to others, further highlighting the role of emotion recognition and knowledge in social-emotional functioning.

As with BER results discussed above, aspects of the stimuli and paradigm may have influenced the results. For instance, the unique configuration and valence of happy and neutral facial features compared to the other basic facial emotions could have informed compensatory strategies. For instance, by using a forced-choice format, a process of elimination based on featural differences, especially for faces, to arrive at an answer was plausible (DiGirolamo & Russell, 2017).

Eye Gaze

The next set of research questions in the pilot study related to how TD participants in middle to older childhood visually process bodily and facial emotional expressions. Specifically, do they visually scan and process consistent with the broader literature, focusing on core diagnostic areas in each modality? In addition, we also examined the question of whether age and sex affected outcomes.

Eye Gaze during BER

As hypothesized, when viewing bodies, participants generally looked longer and more often towards the upper body regions than lower body regions across emotions, shown in the limited eye-tracking literature (Pollux et al., 2019). This was especially true for the torso region, possibly reflecting its overall size in the images relative to other regions as well as research showing that posturing of this area is involved in the accurate expression and recognition of all the emotions shown in the current study (Coulson, 2004; Wallbott, 1998; Witkower & Tracy, 2019).

This may not be true for other body areas. Ross and Flack (2020) recently showed that adults' BER accuracy dropped significantly for angry and fearful but not for happy and sad expressions when the actors' hands were masked. Indeed, participants in the pilot study fixated more to and longer on hands than lower body regions across angry, happy, and fearful expressions. A similar pattern was also seen for arms. Only the legs received more visual attention and only during sad and neutral expressions. In all, it appears that TD, 7-11-year-old children in this pilot study show a largely typical, upper body > lower body, visual processing style for bodily expressions.

Interestingly, as mentioned, legs emerged as a major target of visual attention in sad and neutral expressions. Similar to unexpected findings above, it is possible participants looked towards legs due to stimuli characteristics rather than actual interest in that area. Notably, the hands in both sad and neutral expressions either rested in front of or to the side of the actors' legs. Therefore, increased fixation on the legs may actually reflect visual attention intended for the hands.

Age and Sex in Eye-tracking during BER

Contrary to hypotheses, no age or sex effects were associated with visual processing of bodily emotion expressions. Similar to BER performance, it is possible that no major developments in visual scanning of bodily emotions emerge during this time period. This also suggests that the female advantages in FER may not be present yet in bodies at this age.

Eye Gaze during FER

As hypothesized, findings were largely consistent with past research in relation to which areas were fixated. Participants looked longest and most towards the eyes, followed by the mouth and nose regions (Calder et al., 2000; Wegrzyn et al., 2017). It appears that by middle and older childhood, children scan faces in a typical pattern found in the wider facial emotion literature, while also fixating longer and more on facial regions most associated with specific emotions.

Age and Sex in Eye-tracking during FER

As hypothesized, eye gaze behavior was affected by age, although this affect was somewhat limited. Specifically, seven-year-old participants had longer overall dwell times for happy face expressions compared to 10-year-old participants. Although all participants showed 100% recognition for happy faces, younger children may still need more time to process facial information compared to older children who may use that information more efficiently.

Relationship between Eye Gaze and Emotion Recognition

Building on the examination of emotion recognition performance and associated eye gaze behavior, we wondered whether a relationship would emerge between the two related to the specific visual processing style AOIs in each emotion. It was hypothesized that longer time spent fixating upon core diagnostic regions within emotional expressions would relate to better recognition of those expressions.

As hypothesized, looking longer or more often at core body and face areas was related to better accuracy in the pilot study; however, this relationship was found for only a few emotional expressions. Participants who made more fixations on the hands and fixated longer on noses during angry trials more accurately recognized angry expressions, while better BER performance for sad expressions was related to more fixations to arms and the torso and with less time fixating on legs during sad trials. These findings further highlight the importance of core diagnostic areas, especially the upper body in BER performance.

Nevertheless, unexpected results occurred in the opposite direction hypothesized. Participants who made more fixations to sad eyes showed poorer recognition of sad faces, but were more accurate with more fixations to non-core facial features. Poorer recognition of neutral faces was related to increased dwell time for neutral noses, while recognition of fearful faces was connected to more fixations to the hair region. Looking off-person during neutral trials was related to better BER for neutral expressions. At first glance, it is unclear why these relationships emerged. Eyes are often fixated upon first and for longer during sad expressions (Calvo et al., 2018); however, in the pilot study, the negative relationship emerged with fixation count not dwell time. Therefore, more fixations may reflect confusion or uncertainty and multiple attempts to decode the expression from the eyes, which seems plausible given low accuracy for sad faces. This may also be the case for nose fixations in neutral faces. As for the positive correlations with non-core areas, it may be that participants were highly effective in decoding the emotion expressed with a minimal number of fixations, as evidenced by near ceiling performance in the other emotion. Thus, fixations to other areas may reflect their "exploring" of the face for the sake of exploring and not to look for diagnostic information.

In all, results from this pilot study support the presence and importance of core diagnostic regions associated with emotional facial and bodily expressions. However, as mentioned, relatively few significant correlations emerged across emotions. While happy faces were recognized 100% of the time, leaving no variance to correlate with eye-tracking measures, the lack of findings in other emotional contexts is surprising. It is possible that the manner in which humans tend to process others' faces and bodies may provide one potential explanation. TD humans tend to process emotional faces and bodies expressions configurally, as a whole rather than locally (Atkinson et al., 2007; Maurer et al., 2002); however, featural processing may take a bigger when viewing ambiguous expressions (Calvo et al., 2010; Tanaka et al., 2012). From this, it is possible that configural processing led to accurate recognition in some cases (e.g., fear expression), while featural processing was needed more in others (e.g., angry expressions). Using more ambiguous stimuli, such as less intense expressions of emotion, may elicit more associations.

Emotion Recognition and Social-Emotional Functioning

Lastly, we explored the relationship between emotion recognition performance and broad social-emotional functioning. Given the putative role emotion recognition plays in broader emotional knowledge and thus in higher level emotion competencies (Izard et al., 2011), it was hypothesized that better emotion recognition would correlate with better social-emotional functioning. Again, analyses found few overall significant findings.

As hypothesized, we found several significant relationships between emotion recognition performances and measures of social-emotional functioning; however, unexpected relationships emerged in conflict with our hypotheses. Unsurprisingly, better overall FER performance was associated with higher parent-rated social competence and lower parent-ratings of social problems and sluggish cognitive tempo, consistent with and expanding several previous findings (e.g., Castro et al., 2018; Izard et al., 2001). In addition, better recognition of angry bodies was related to reduced levels of anxiety, while better recognition of sad faces was associated with lower levels of withdrawn-depressive symptoms. In line with Izard et al. (2011), the ability to accurately decode certain expressions in their environment may protect against later negative social-emotional outcomes, likely by informing adequate emotion knowledge and subsequent adaptive emotion regulation and use (e.g., coping skills). Further, these findings lend credence to the importance of appropriate emotion recognition in certain internalizing disorders (e.g., Mogg & Bradley, 1998).

Conversely, no significant relationships emerged between overall BER performance and measures of social-emotional functioning. This was surprising given Parker and colleagues' (2013) findings that BER predicted boys' social skills. Nevertheless, it is possible that BER in our sample does relate to social-emotional functioning but when acting in concert with other emotion understanding abilities (e.g., emotion situation understanding), rather than alone. In Fine et al. (2003), the relationship between emotion knowledge (a combination of FER and emotion situation understanding) and children's internalizing behavior was stronger than either FER or emotion situation understanding alone. Moreover, our participants were in middle to older childhood ranges when their social relationships and contexts grow more complex. As a result, their emotion knowledge may need to extend beyond simple emotion expression recognition (Castro et al., 2016).

Additionally, other surprising findings emerged. Better recognition of sad bodies was related to poorer child ratings of self-control and increased levels of parent-rated social problems and sluggish cognitive tempo. It is unclear why this pattern emerged, especially given the fact that better recognition of sad faces was related to higher levels of parent-rated social competence. It is possible that this pattern represents an immature and ineffective emotion processing style. Participants in Actis-Grosso et al. (2015) showed a flexible processing style, in which they appeared to prefer bodies when decoding fear but faces for sadness. Thus, individuals who show a body preference when decoding sadness may be slower to process social-emotional information, thereby presenting as less competent both with others and themselves. Similarly confusing was the relationship between better recognition of neutral faces and better social competence but lower academic self-efficacy. As discussed above, understanding whether someone is feeling emotional or not is important to proper social-emotional functioning. Although the relationship with poorer academic self-efficacy is unclear, the sample in the pilot study was taken largely from students with some level of academic difficulty, given the nature of the larger study. It is possible, then, that a different directional relationship would emerge in a community sample.

Limitations

Several limitations were associated with the pilot study, many of which have already been discussed. These include the use of static, basic expressions. Dynamic displays and/or more complex emotions may elicit more and different results. Further, the test procedures could prove a limitation. In the current study, the participants verbalized their answers to the examiner who recorded them. While this was done to reduce distraction within child participants, it prohibited tracking other relevant data, such as reaction time. Moreover, using a forced-choice paradigm allowed for better analysis of differences within specific emotion, but it may also have inflated certain performances, as already noted above. A long display time was also used. Although we tried to control for that by only taking eye gaze data from the first few seconds of a trial, participants may have adjusted their eye movements based on their knowledge of long trials. Similarly, a fixation point was used to direct participants' attention to the screen;

however, it was inadvertently located in the middle, likely inflating fixation data for whichever AOI appeared in that spot. Although we tried to adjust for this by further adjusting the data collected to begin after the end of the first fixation, different results may emerge had this been controlled for. In addition, dwell time was collected, representing raw time participants fixated upon specific AOIs. A better option may be to collect proportion of fixation time, which can protect against missing or invalid events (e.g., blinks, loss of connection) during trials. Lastly, our sample size was a limitation. Especially when broken down by age group, there were a limited number in each age band.

Implications for Future Research in ASD

As a pilot study, this research was done to inform future research with individuals with ASD and others. The pilot study managed to find several within-subject eye gaze differences across AOIs for each amotion, as well as recognition differences across emotions and modalities. Motivated by this, we expect to be able to find within and between subject differences in future studies in ASD for both faces and bodies. However, it is not possible to hypothesize what differences would emerge regarding body expressions due to the lack of research. However, we have more data with which to guide and examine possible differences in the future.

Nevertheless, the pilot study shed light on some considerations that may be especially important when studying the ASD population. Although we expected to find several age and sex effects, this was not necessarily the case. As noted, this study had several limitations, some of which were due to poor design and others inherent to certain tasks and stimuli. For instance, the uneven sex and age groups and small sample sizes within each age band likely played a large part in our limited findings, while using a forced-choice task may have informed certain strategy use when answering (DiGirolamo & Russell, 2017). With this in mind, future research with individuals identified with ASD should be even more vigilant for possible confounds, given the presence of previously reviewed factors possibly affecting ASD emotion recognition results (e.g., verbal ability, ASD severity; Harms et al., 2010). Carefully matching comparison groups across several participant characteristics, while also including different recognition tasks within a single study (e.g., free labelling, matching) may protect against some artifacts.

TD research has suggested that eye movement patterns seen in isolated modalities are affected by the information presented in face-body combinations (Kret, Roelofs, et al., 2013; Kret, Stekelenburg, et al., 2013; Nelson & Mondloch, 2013). Thus, laboratory-based findings of emotional face or body processing patterns may not reflect real-world scenarios. Given several findings of atypical visual scanning for emotional faces and a possible body bias in ASD in combination with emotion recognition deficits, examining face-body compounds will be of particular interest in informing possible future interventions.

Lastly, the pilot study suggests that our current paradigm and analyses can likely uncover recognition and general eye gaze differences; however, additional measures and analyses may provide even more nuanced assessment of group differences. For instance, analyzing the specific errors that participants make when answering may provide additional information. If participants systematically misattribute certain emotions to other expressions (e.g., misidentifying sad expressions as neutral) this could point to further lines of research as well as intervention. In another type of measure, Spezio et al. (2007) used the “bubbles” technique during eye-tracking tasks with ASD participants for an even finer-grained analysis of the diagnostic facial features within emotions. In this technique, the resolution of an image is dampened by covering the face with several “bubbles” of the same size, prohibiting configural processing. Then, small regions of the stimulus are uncovered by taking away one bubble at a time. Diagnostic feature are related to which specific bubbles were removed and which features were uncovered. The bubbles technique can be applied in conjunction with eye-tracking to see not only specific regional importance but also how individuals with ASD scan for this information compared to controls, and how their scanning changes with the addition of new uncovered features. Moreover, this has not been widely used for bodily emotions, especially in ASD. Likewise, using eye-tracking to not only look for overall eye gaze differences within regions but how they move from one region to the next can provide another method for examining differences. This has been done for face (Hernandez et al., 2009; Kliemann et al., 2012) but not for bodies.

Conclusion

In conclusion, results of this pilot study suggest that TD children show differential recognition accuracy across different emotions when expressed in either the face or body. Moreover, a definite face advantage exists for certain emotions, especially for happiness. During emotion recognition tasks, TD children’s eye movements largely reflect those found in the broader emotion processing literature, indicating that children as young as seven years scan emotional faces and bodies by largely focusing on core diagnostic areas associated with specific emotional expression in the face and body. However, despite perceiving and processing information from these core areas, doing so is not necessarily related to recognition accuracy. Likewise, recognition accuracy is variably related to broader social-emotional functioning with better outcomes associated with the facial emotion recognition; however, basic emotion recognition alone may not be the optimal index of emotion knowledge as children age.

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APPENDIX A

Table 1

Studies examining emotion perception in bodies and bodies with faces

Citation	Participants: N, group (mean age in years)	Matching variables	Task	Stimuli	Emotions	Outcome Variable	Significant Difference
Bodies Only							
Moore et al., 1997 (Experiment 3)	13 ASD (14.75); 13 ID (14.17); 13 TD (7.92)	VIQ (ID, TD); CA (ID)	VL	PLD	H, Sa, A, F, Su	RA	BER: TD, ID>ASD (H, Sa, A, F)
Hubert et al., 2006	19 ASD (21.5); 19 TD (24.3)	CA, Sex	VL	PLD	H, Sa, A, F, Su	RA	BER: TD>ASD
Hadjikhani et al., 2009	11 ASD (30), 11 TD (31)	Not reported	FCMtS	SI	Sa, A, F	RA	BER: TD > ASD
Philip et al., 2010	23 ASD (32.5), 23 TD (32.4)	CA, Sex	FCL FCMtS	FC, SI, AC	H, Sa, A, D, F	RA	BER: TD > ASD; FER: SI FCL TD > ASD (A, Sa, F), FCMtS (S); Voices: TD > ASD
Atkinson, 2009	13 ASD (30.9), 16 TD (26.7)	CA, FSIQ, VIQ, NVIQ	FCL	PLD; FC	H, Sa, A, D, F	RA	BER: TD > ASD (H, A, D)

Table 1 (continued).

Citation	Participants: N, group (mean age in years)	Matching variables	Task	Stimuli	Emotions	Outcome Variable	Significant Difference
Doody & Bull, 2011	20 ASD (15.8); 20 TD (15.94)	CA, FSIQ, VIQ, NVIQ, Visual-Perceptual ability	FCMtS; FCL	SA	Bored, Interested, Disagreeing, Agreeing	RA, RT	BER: FCMtS RT TD < ASD, FCL RT TD > ASD (bored), FCL RT TD < ASD (bored, interested)
Doody & Bull, 2013	20 HF-ASD (15.9), 20 TD (16.03)	CA, FSIQ, VIQ, NVIQ, Visual-Perceptual ability	FCMtS; FCL	SA	6 basic	RA, RT	BER: FCMtS RT TD < ASD (A), FCL TD > ASD (F)
Metcalfe et al., 2019	27 ASD (10.9); 27 TD (10.9)	CA, Sex	VL	DA	6 basic; boredom, worry	RA	ASD < TD
Bodies and Faces							
Fridenson-Hayo et al., 2016	55 ASD (7.61), 58 TD (7.55)	CA, FSIQ, Sex	FCL	FC	6 basic; 12 complex	RA	TD > ASD (all modalities)
Peterson et al., 2015	Study 1:34 ASD (9.48), 41 TD (8.85); Study 2: 33 ASD (9.7), 31 TD (9.37)	Study 1: CA, VIQ; Study 2: CA	FCL	SI	6 basic, 12 complex	RA	Study 1: FER: TD > ASD; Study 2: FER: TD > ASD

Table 1 (continued).

Citation	Participants: N, group (mean age in years)	Matching variables	Task	Stimuli	Emotions	Outcome Variable	Significant Difference
Actis-Grosso et al., 2015	20 ASD (22.8); 25 TD (22.3)	None reported	FCL	PLD, SI	H, Sa, A, F	RA	ASD: faces > PLDs (F); TD: PLDs > face (F), face > PLDs (Sa)
Brewer et al., 2017	19 ASD (34.84); 27 TD (33.85)	CA, FSIQ, Sex	VL	SI	A, D	RA	No group differences
Eye-tracking							
Klin, et al., 2002	15 ASD (15.4) ; 15 (17.9) TD	CA, VIQ	PV	FC	NS	FD	ASD > TD (mouth, body, other); TD < ASD (eyes)
Speer et al., 2007	12 ASD (13.6), 12 TD (13.3)	CA, VIQ, NVIQ Sex	PV	FC, SI	NS	FD	Bodies: ASD > TD (social clips); Eyes: ASD < TD (social clips)

Table 1 (continued).

Citation	Participants: N, group (mean age in years)	Matching variables	Task	Stimuli	Emotions	Outcome Variable	Significant Difference
Riby & Hancock, 2009	20 ASD (13.3); 16 Williams Syndrome (17.5); 72 TD (5.25 - 17.5)	CA, NVIQ	PV	SI, SA, FC, DA	NS	FD	Bodies: ASD > CA/NVIQ - TD (SA), ASD > CA - TD (FC), ASD > NVIQ - TD (FC); Face: ASD < CA + NVIQ - TD (all); background: ASD > CA - TD (all), ASD > NVIQ - TD (FC); Eyes: ASD < CA/NVIQ - TD (SA, FC); Mouth: ASD < CA - TD (FC)

Table 1 (continued).

Citation	Participants: N, group (mean age in years)	Matching variables	Task	Stimuli	Emotions	Outcome Variable	Significant Difference
Nackaerts et al., 2012	12 ASD (34.9); 12 TD (31.5)	CA, VIQ, NVIQ, FSIQ	FCL	PLD	H, Sa, A, N	RA, RT, SC, FD	ASD < TD (RA, FD); ASD > TD (RT, SC)
Hanley et al., 2013	14 ASD (20.6); 14 TD (20.3)	CA, VIQ, NVIQ, Sex		SI	H, Sa, A, F, D; excited, sorry, romantic, bored, thinking	FD	Exaggerated social images: ASD > TD (bodies), TD > ASD (eyes); naturalistic social images: ASD > TD (bodies, mouth, nose, hair, background, objects), TD > ASD (face, eyes)

Note. A = Anger, AC = Auditory Clip, ASD = Autism Spectrum Disorder, CA = Chronological Age, D = Disgust, DA = Dynamic Animation, F = Fear, FC = Film Clip, FCL = Forced-Choice Label, FD = Fixation Duration, FCMtS = Forced-Choice Match-to-Sample, FSIQ = Full Scale IQ, H = Happiness, ID = Intellectual Disability, N = Neutral, NS = Nonspecific, NVIQ = Nonverbal IQ, PV = Passive Viewing, RA = Recognition Accuracy, RT = Reaction Time, Sa = Sadness, SA = Static

Animation, SI = Static Image, Su = Surprise, SC = Saccade Count, TD = Typically Developing, VIQ = Verbal IQ, VL = Verbal Label

APPENDIX B

Table 2

Participant demographic information

Variable	N	Mean	SD	%
Age (years)	41	9.36	1.28	
Age Groups				
7 years	7			17%
8 years	9			22%
9 years	12			29%
10 years	8			20%
11 years	5			12%
Sex				
Male	24			59%
Female	17			42%
Race/Ethnicity				
Caucasian	24			12%
Asian/Pacific Islander	5			2%
Hispanic	8			20%
Black/African American	1			59%
Other	2			5%
Missing	1			2%
Language in Home				
English	33			81%
Spanish	1			2%
Other	1			2%
Bilingual	5			12%
Missing	1			2%

Note. N = Number, SD = Standard Deviation

Table 3

Proportion of correctly identified trials during the BER task across emotion, age group, and sex

	7 years				8 years				9 years			
	Male		Female		Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Anger	0.80	0.45	0.88	0.18	0.71	0.33	0.75	0.25	0.79	0.19	0.63	0.41
Happy	0.40	0.55	0.50	0.71	0.38	0.26	0.17	0.29	0.50	0.22	0.21	0.25
Sad	0.30	0.45	0.63	0.53	0.17	0.20	0.33	0.58	0.71	0.25	0.50	0.47
Fear	0.70	0.41	1.00	0.00	0.54	0.37	0.92	0.14	0.96	0.10	0.75	0.16
Neutral	0.80	0.33	0.88	0.18	0.67	0.26	0.83	0.29	0.63	0.26	0.58	0.13

Table 3 (continued).

	10 years				11 years			
	Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Anger	0.88	0.14	0.94	0.13	0.75	0.25	0.88	0.18
Happy	0.69	0.47	0.25	0.35	0.50	0.43	0.13	0.18
Sad	0.19	0.38	0.56	0.43	0.42	0.38	0.50	0.00
Fear	0.81	0.24	0.81	0.13	0.92	0.14	0.75	0.00
Neutral	0.88	0.14	0.94	0.13	0.67	0.14	1.00	0.00

Note. BER = Bodily Emotion Recognition, SD = Standard Deviation

Table 3

Results of ANOVA comparing recognition performance within BER trials

Tests of Within-Subjects Effects				
Variable	df	F	*p*	η_p^2
Emotion	4	22.64	<.001	0.42
Emotion x Age Group	16	0.97	0.50	0.11
Emotion x Sex	4	2.83	0.03	0.08
Emotion x Age Group x Sex	16	0.64	0.84	0.08
Error	124			

Tests of Between-Subjects Effects				
Variable	df	F	*p*	η_p^2
Intercept	1	385	0	0.925
Age Group	4	0.735	0.575	0.087
Sex	1	0.119	0.733	0.004
Age Group x Sex	4	1.13	0.36	0.127
Error	31			

Note. ANOVA = Analysis of Variance, BER = Bodily Emotion Recognition

Table 4

Proportion of correctly identified trials during the FER task across emotion, age group, and sex

Emotion	7 years				8 years				9 years			
	Male		Female		Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Anger	0.90	0.22	0.75	0.35	1.00	0.00	1.00	0.00	0.75	0.27	1.00	0.00
Happy	1.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00
Sad	0.60	0.42	0.75	0.35	0.50	0.32	0.67	0.29	0.58	0.38	0.67	0.26
Fear	0.70	0.45	1.00	0.00	0.92	0.20	1.00	0.00	0.67	0.26	0.75	0.42
Neutral	0.80	0.27	1.00	0.00	1.00	0.00	1.00	0.00	0.92	0.20	1.00	0.00

Table 5 (continued).

Emotion	10 years				11 years			
	Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Anger	0.88	0.25	1.00	0.00	0.67	0.29	1.00	0.00
Happy	1.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00
Sad	0.63	0.25	0.25	0.29	0.33	0.29	0.25	0.35
Fear	0.88	0.25	0.88	0.25	0.67	0.29	1.00	0.00
Neutral	1.00	0.00	1.00	0.00	0.67	0.29	1.00	0.00

Note. FER = Facial Emotion Recognition, SD = Standard Deviation

Table 5

Results of ANOVA comparing recognition performance within FER trials

Tests of Within-Subjects Effects				
Variable	df	F	*p*	η_p^2
Emotion	2.50	24.41	<.001	0.44
Emotion x Age Group	9.98	1.05	.41	0.12
Emotion x Sex	2.50	1.06	.37	0.03
Emotion X Age Group x	9.98	0.81	.62	0.10
Error (Face Emotion)	77.36			

Tests of Between-Subjects Effects				
Variable	df	F	*p*	η_p^2
Intercept	1	2396.96	<.001	0.99
Age Group	4	1.71	.17	0.18
Sex	1	4.99	.03	0.14
Age Group x Sex	4	1.19	.33	0.13
Error	31			

Note. ANOVA = Analysis of Variance, FER = Facial Emotion Recognition

Table 6

Results of ANOVA comparing recognition performance across modalities

Tests of Within-Subjects Effects				
Variable	df	F	*p*	η_p^2
Emotion	4	28.402	<.001	0.48
Emotion x Age Group	16	1.136	.33	0.13
Emotion x Sex	4	2.57	.04	0.08
Emotion X Age Group x	16	0.568	.90	0.07
Error (Emotion)	124	34.897	<.001	0.53
Modality	1	1.706	.17	0.18
Modality x Age Group	4	0.643	.43	0.02
Modality x Sex	1	1.568	.21	0.17
Modality x Age Group x Sex	4	17.682	<.001	0.36
Error (Modality)	31	0.851	.60	0.10
Emotion x Modality	2.99	1.614	.19	0.05
Emotion x Modality x Age Group	11.98	0.872	.58	0.10
Emotion x Modality x Sex	2.99			
Emotion x Modality x Age Group x Sex	11.98			
Error (Emotion x Modality)	92.81			

Tests of Between-Subjects Effects				
Variable	df	F	*p*	η_p^2
Intercept	1	1389.19	<.001	0.98
Age Group	4	0.40	.81	0.05
Sex	1	1.56	.22	0.05
Age Group x Sex	4	0.84	.51	0.10
Error	31			

Note. BER = Bodily Emotion Recognition, FER = Facial Emotion Recognition

Table 7

Mean dwell time (msec) on AOIs across sex and age groups during recognition trials for angry bodily expressions

	7 years				8 years				9 years			
	Male		Female		Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Torso	1047.43	126.53	988.00	246.78	1211.50	283.50	948.00	415.65	1106.75	244.37	1064.83	328.74
Neck	92.20	112.09	93.00	0.00	88.00	107.79	0.00	0.00	58.50	110.88	97.08	131.48
Hands	731.30	231.88	675.75	377.24	386.25	213.85	319.50	291.63	273.42	184.07	442.25	232.92
Arms	385.30	119.97	358.00	217.79	100.50	93.53	365.50	241.64	342.25	197.20	410.33	277.10
Legs	248.70	165.79	296.50	347.90	444.58	282.54	385.33	117.33	310.33	98.19	268.42	87.17
Feet	24.27	33.79	0.00	0.00	73.00	65.88	126.67	146.54	102.25	146.17	71.83	123.98
Off Person	38.67	60.19	65.50	92.63	15.75	26.60	85.33	87.58	181.83	73.68	97.33	77.57

Table 9 (continued).

	10 years				11 years			
	Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Torso	1178.88	203.73	1049.38	246.68	1181.17	137.75	1080.75	664.33
Neck	31.63	38.20	10.50	21.00	0.00	0.00	178.75	115.61
Hands	328.00	202.72	334.38	322.35	196.17	183.38	356.50	166.17
Arms	520.63	420.46	415.13	104.73	310.50	38.75	127.50	17.68
Legs	304.63	253.56	254.63	128.30	173.17	160.36	231.25	63.99
Feet	9.13	18.25	133.38	159.71	7.67	13.28	45.50	2.83
Off Person	59.88	65.79	68.38	18.43	14.83	25.69	130.25	17.32

Note. AOI = Area of Interest, SD = Standard Deviation

Table 8

Mean dwell time (msec) on AOIs across sex and age groups during recognition trials for happy bodily expressions

AOI	7 years				8 years				9 years			
	Male		Female		Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Torso	954.70	119.39	456.00	79.90	825.67	439.64	800.50	207.43	968.00	133.09	782.83	245.64
Neck	148.10	120.90	80.75	114.20	161.42	156.77	47.17	42.37	160.33	128.99	109.08	111.82
Hands	387.80	230.48	631.00	452.55	379.50	227.91	265.83	83.85	398.58	229.95	361.33	301.80
Arms	618.50	212.75	227.50	56.57	475.17	328.47	480.33	232.92	495.50	160.58	659.33	300.44
Legs	272.80	87.86	347.25	149.55	194.17	82.61	462.50	168.13	240.83	231.26	371.08	292.26
Feet	44.10	36.42	0.00	0.00	101.58	127.90	200.83	78.30	122.25	139.47	39.08	84.97
Off Person	172.80	114.79	181.75	69.65	114.75	92.20	169.17	93.08	165.42	70.20	137.25	119.14

Table 9 (continued).

AOI	10 years				11 years			
	Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Torso	915.50	400.97	852.00	273.58	1173.33	143.09	1069.75	82.38
Neck	98.63	115.14	107.00	72.31	66.33	64.58	128.00	181.02
Hands	304.63	240.40	319.63	127.91	81.50	72.54	374.50	162.63
Arms	646.75	410.37	724.75	268.18	399.67	144.24	317.00	41.72
Legs	435.38	226.31	231.88	200.07	315.00	208.26	258.50	185.26
Feet	67.88	55.81	39.38	46.76	10.67	18.48	93.50	132.23
Off Person	88.50	79.07	172.38	146.85	112.33	51.81	105.25	6.01

Note. AOI = Area of Interest, SD = Standard Deviation

Table 9

Mean dwell time (msec) on AOIs across sex and age groups during recognition trials for sad bodily expressions

AOI	7 years				8 years				9 years			
	Male		Female		Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Torso	1015.20	416.43	645.50	296.28	827.92	237.03	521.17	308.55	729.33	324.86	867.50	270.21
Neck	172.70	250.02	42.25	59.75	144.83	154.07	27.67	47.92	73.75	94.00	46.42	67.94
Hands	273.60	233.84	414.75	179.25	237.58	147.42	495.33	461.50	341.67	161.62	395.50	298.27
Arms	73.10	85.31	512.50	410.83	80.67	77.39	83.50	55.83	221.17	223.89	118.33	109.26
Legs	682.20	171.94	770.25	94.40	706.17	260.07	825.50	383.36	597.50	178.66	717.58	355.06
Feet	50.60	70.20	0.00	0.00	90.33	163.58	109.67	69.76	62.67	107.91	34.92	55.66
Off Person	70.00	109.07	90.25	127.63	9.42	22.58	129.50	19.79	169.92	203.32	196.25	215.44

Table 10 (continued)

AOI	10 years				11 years			
	Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Torso	828.13	452.76	845.50	407.89	1298.17	510.10	1018.75	389.26
Neck	59.50	46.09	27.13	35.04	0.00	0.00	0.00	0.00
Hands	220.38	178.31	233.13	241.63	197.67	153.87	303.25	234.41
Arms	125.38	198.23	65.00	54.65	93.33	95.31	181.50	141.42
Legs	906.38	183.10	726.25	379.48	551.33	88.91	731.25	196.93
Feet	112.50	204.54	140.25	131.39	8.50	14.72	63.50	89.80
Off Person	28.50	33.81	49.88	81.80	102.50	127.70	71.50	2.12

Note. AOI = Area of Interest, SD = Standard Deviation

Table 10

Mean dwell time (msec) on AOIs across sex and age groups during recognition trials for fearful bodily expressions

AOI	7 years				8 years				9 years			
	Male		Female		Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Torso	774.70	212.86	604.50	476.59	690.42	204.65	867.28	250.56	808.92	162.85	941.75	401.66
Neck	439.50	266.74	666.50	643.47	505.75	238.03	157.67	218.44	370.00	259.12	313.08	330.50
Hands	299.60	194.31	520.25	170.77	164.67	114.87	230.94	145.76	309.92	177.75	285.25	179.16
Arms	309.00	182.66	289.00	67.18	360.33	245.27	454.89	174.49	351.92	188.44	551.42	184.65
Legs	180.90	115.01	1.25	0.35	304.00	264.81	308.33	249.44	189.25	137.56	269.42	190.17
Feet	361.50	201.14	359.25	213.19	358.17	228.85	340.06	134.66	336.92	114.17	244.50	134.10
Off Person	202.60	125.58	133.00	188.09	166.50	98.74	271.00	63.98	206.08	182.45	124.08	134.95

Table 11 (continued)

AOI	10 years				11 years			
	Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Torso	990.13	253.45	690.75	259.57	715.83	326.21	618.25	235.82
Neck	323.75	427.56	349.00	70.95	242.83	302.95	378.25	534.93
Hands	279.75	188.39	303.13	170.21	131.83	37.14	297.50	28.99
Arms	333.63	120.84	334.00	106.92	596.83	495.85	173.25	27.93
Legs	188.38	197.44	357.63	195.09	94.83	128.66	191.75	138.24
Feet	394.63	203.48	256.88	115.15	347.33	113.04	452.00	43.84
Off Person	49.75	69.09	95.75	98.57	88.67	85.68	278.25	336.94

Note. AOI = Area of Interest, SD = Standard Deviation

Table 11

Mean dwell time (msec) on AOIs across sex and age groups during recognition trials for neutral bodily expressions

AOI	7 years				8 years				9 years			
	Male		Female		Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Torso	1103.30	211.64	568.75	267.64	934.17	284.75	639.50	36.76	928.83	401.16	993.92	379.19
Neck	193.10	177.01	39.00	55.15	221.75	146.97	0.00	0.00	162.25	182.20	145.00	226.59
Hands	181.60	185.84	559.50	791.25	226.92	143.85	364.17	180.63	159.25	95.93	235.33	203.75
Arms	78.70	77.79	305.75	230.16	79.17	88.53	0.00	0.00	78.92	142.97	87.58	159.07
Legs	641.60	160.18	702.50	662.56	710.17	234.22	1051.67	51.36	882.75	468.29	778.92	263.33
Feet	174.70	99.92	118.00	166.88	30.42	47.48	175.67	72.97	66.75	81.71	68.92	88.30
Off Person	54.20	56.79	110.25	24.40	120.17	125.98	140.67	174.90	39.25	37.18	66.00	58.74

Table 12 (continued)

AOI	10 years				11 years			
	Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Torso	1213.00	471.81	980.38	514.35	1125.17	338.65	1653.75	1189.71
Neck	62.63	72.84	127.88	255.75	40.17	69.57	0.00	0.00
Hands	204.25	114.88	302.75	293.34	81.00	70.36	103.50	146.37
Arms	32.38	43.71	70.75	46.40	12.17	21.07	0.00	0.00
Legs	691.00	308.05	589.88	323.59	673.67	435.66	423.25	381.48
Feet	97.00	144.08	101.75	131.93	0.00	0.00	32.25	45.61
Off Person	59.63	71.20	116.75	83.87	69.83	66.96	40.25	56.92

Note. AOI = Area of Interest, SD = Standard Deviation

Table 12

Results of ANOVA comparing dwell time differences during BER trials

Within-Subjects Effects				
Variable	df	F	*p*	η_p^2
Emotion	4	5.87	<.001	0.16
Emotion x Age Group	16	1.25	.24	0.14
Emotion x Sex	4	0.75	.56	0.02
Emotion x Age Group x Sex	16	0.73	.76	0.09
Error (Emotion)	124	140.77	<.001	0.82
AOI	2.90	1.40	.18	0.15
AOI x Age Group	11.60	1.83	.15	0.06
AOI x Sex	2.90	0.66	.78	0.08
AOI x Age Group x Sex	11.60	23.47	<.001	0.43
Error (AOI)	89.88	1.11	.31	0.13
Emotion x AOI	9.61	0.36	.96	0.01
Emotion x AOI x Age Group	38.43	1.14	.28	0.13
Emotion x AOI x Sex	9.61			
Emotion x AOI x Age Group x Sex	38.43			
Error (Emotion x AOI)	297.79			

Between-Subjects Effects				
Variable	df	F	*p*	η_p^2
Intercept	1	3251.54	<.001	0.99
Age Group	4	0.95	.45	0.11
Sex	1	0.03	.88	0.00
Age Group x Sex	4	0.57	.69	0.07
Error	31			

Note. ANOVA = Analysis of Variance, AOI = Area of Interest, BER = Bodily Emotion Recognition, SD = Standard Deviation

Table 13

Mean dwell time (msec) on AOIs across sex and age groups during recognition trials for angry facial expressions

AOI	7 years				8 years				9 years			
	Male		Female		Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Eyes	1176.00	736.28	601.00	15.56	856.67	408.75	819.00	158.69	757.17	639.00	804.00	403.54
Nose	629.60	243.86	663.00	315.37	696.50	174.64	626.00	370.00	480.33	470.73	637.67	222.24
Mouth	212.00	268.94	658.00	152.74	535.33	411.57	644.00	155.01	701.33	339.74	364.17	276.81
Other Face	322.20	470.05	580.00	19.80	263.50	102.20	407.33	351.49	562.33	603.98	511.50	209.52
Hair	37.80	84.52	5.50	7.78	0.00	0.00	0.00	0.00	48.50	118.80	77.17	134.80
Neck	0.00	0.00	166.00	234.76	32.17	78.79	0.00	0.00	0.00	0.00	0.00	0.00
Off Face	0.00	0.00	0.00	0.00	55.50	88.40	21.33	36.95	63.00	148.04	0.00	0.00

Table 14 (continued).

AOI	10 years				11 years			
	Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Eyes	611.75	527.64	1215.25	344.31	1023.33	121.18	807.50	787.01
Nose	553.25	208.45	250.50	146.97	732.00	87.28	546.00	661.85
Mouth	449.50	84.39	382.75	269.58	137.67	165.99	647.00	22.63
Other Face	488.75	446.58	311.75	173.24	254.67	175.35	290.00	56.57
Hair	0.00	0.00	0.00	0.00	40.33	69.86	0.00	0.00
Neck	61.50	123.00	0.00	0.00	0.00	0.00	0.00	0.00
Off Face	60.00	120.00	100.00	200.00	0.00	0.00	0.00	0.00

Note. AOI = Area of Interest, SD = Standard Deviation

Table 14

Mean dwell time (msec) on AOIs across sex and age groups during recognition trials for happy facial expressions

AOI	7 years				8 years				9 years			
	Male		Female		Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Eyes	1192.60	890.81	892.00	453.96	712.00	529.58	889.67	827.10	789.17	754.49	741.00	393.60
Nose	630.60	369.84	689.50	241.12	544.33	233.08	577.67	87.20	567.83	406.42	460.67	254.77
Mouth	574.80	489.06	931.50	559.32	747.67	479.47	656.00	418.49	988.17	793.27	948.50	553.22
Other Face	173.40	163.64	180.50	255.27	347.50	243.84	238.00	210.55	193.33	220.22	249.83	122.63
Hair	61.00	136.40	0.00	0.00	173.83	243.14	133.00	144.65	68.83	98.42	66.17	150.62
Neck	8.60	19.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Off Face	0.00	0.00	0.00	0.00	44.17	68.95	0.00	0.00	0.00	0.00	0.00	0.00

Table 15 (continued)

AOI	10 years				11 years			
	Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Eyes	651.00	603.75	819.25	356.94	930.00	306.83	905.50	907.22
Nose	384.50	159.17	301.75	198.43	461.00	183.00	243.50	95.46
Mouth	701.25	316.57	762.25	491.81	345.00	278.38	757.50	85.56
Other Face	283.00	244.09	419.50	238.17	388.33	262.24	225.00	236.17
Hair	0.00	0.00	37.25	74.50	113.00	195.72	56.00	79.20
Neck	40.75	81.50	0.00	0.00	0.00	0.00	12.50	17.68
Off Face	50.25	100.50	15.50	31.00	0.00	0.00	0.00	0.00

Note. AOI = Area of Interest, SD = Standard Deviation

Table 15

Mean dwell time (msec) on AOIs across sex and age groups during recognition trials for sad facial expressions

AOI	7 years				8 years				9 years			
	Male		Female		Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Eyes	1096.00	1018.62	953.50	542.35	1053.33	725.51	1112.67	505.92	737.00	488.56	1095.67	594.60
Nose	515.00	327.49	692.50	235.47	604.33	417.18	569.67	241.43	744.50	381.54	448.50	291.50
Mouth	412.80	376.84	356.50	195.87	288.50	345.02	460.67	274.96	498.50	388.94	324.33	350.06
Other Face	304.00	170.56	178.50	109.60	230.50	151.73	195.33	249.21	574.00	429.05	586.00	357.34
Hair	0.00	0.00	34.00	48.08	19.67	48.17	116.67	201.21	34.33	53.64	0.00	0.00
Neck	0.00	0.00	18.00	25.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Off Face	30.00	67.08	5.50	7.78	0.00	0.00	0.00	0.00	10.50	25.72	8.50	20.82

Table 16 (continued).

AOI	10 years				11 years			
	Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Eyes	1279.50	633.17	1624.00	425.52	1296.67	175.91	956.50	368.40
Nose	676.50	444.94	247.25	205.24	594.00	523.64	190.50	267.99
Mouth	322.50	326.63	256.50	179.09	14.33	24.83	597.50	679.53
Other Face	244.50	118.72	302.75	303.79	286.33	320.14	633.00	715.59
Hair	41.00	82.00	72.50	86.17	210.00	363.73	0.00	0.00
Neck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Off Face	4.00	8.00	0.00	0.00	0.00	0.00	105.00	91.92

Note. AOI = Area of Interest, SD = Standard Deviation

Table 16

Mean dwell time (msec) on AOIs across sex and age groups during recognition trials for fearful facial expressions

	7 years				8 years				9 years			
	Male		Female		Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Eyes	1268.60	731.03	1542.00	181.02	1117.83	628.47	1432.00	290.19	922.33	624.55	970.00	468.99
Nose	504.00	219.44	393.50	375.47	818.00	565.25	427.00	159.34	639.33	468.12	584.00	424.67
Mouth	263.80	232.94	467.50	392.44	355.33	378.58	424.00	437.58	551.17	533.91	360.33	276.45
Other Face	303.80	227.46	243.50	177.48	226.17	159.68	253.67	79.48	304.50	269.63	397.50	271.58
Hair	85.80	123.21	5.50	7.78	0.00	0.00	12.00	20.78	28.00	68.59	25.50	62.46
Neck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.00	44.09
Off Face	0.00	0.00	0.00	0.00	8.00	20.00	10.00	17.00	5.00	12.00	0.00	0.00

Table 17 (continued).

	10 years				11 years			
	Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Eyes	1120.00	886.91	1596.50	265.43	1935.67	508.58	1250.50	1259.36
Nose	799.00	492.30	379.00	169.99	534.67	381.60	316.50	279.31
Mouth	427.00	309.77	304.00	240.69	40.00	69.28	526.50	224.15
Other Face	202.25	309.73	175.00	100.65	67.33	116.62	159.00	142.84
Hair	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Neck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Off Face	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note. AOI = Area of Interest, SD = Standard Deviation

Table 17

Mean dwell time (msec) on AOIs across sex and age groups during recognition trials for neutral facial expressio

	7 years				8 years				9 years			
	Male		Female		Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Eyes	1289.00	272.64	1011.50	351.43	1023.67	563.75	864.67	333.20	848.50	681.31	890.50	538.51
Nose	674.00	360.35	740.50	481.54	765.83	312.47	371.33	122.52	548.00	379.97	785.17	463.14
Mouth	470.00	352.23	409.50	191.63	353.50	267.83	488.33	618.63	592.83	470.96	361.33	337.68
Other Face	126.60	66.07	312.50	301.93	167.67	234.18	245.00	178.30	285.50	259.66	231.00	284.73
Hair	47.60	70.23	0.00	0.00	13.17	32.25	116.33	108.96	76.00	121.28	90.17	145.88
Neck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Off Face	11.00	24.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	9.00	0.00	0.00

Table 18 (continued).

	10 years				11 years			
	Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Eyes	680.75	508.50	1436.75	362.35	627.33	386.00	1117.50	238.29
Nose	997.50	429.99	369.25	198.29	733.33	884.91	205.50	157.68
Mouth	537.25	436.32	262.50	133.61	49.00	84.87	740.00	363.45
Other Face	173.25	129.38	170.00	132.20	975.00	719.48	93.50	34.65
Hair	0.00	0.00	44.25	88.50	21.00	36.37	386.00	545.89
Neck	27.25	54.50	0.00	0.00	0.00	0.00	0.00	0.00
Off Face	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note . AOI = Area of Interest, SD = Standard Deviation

Table 18

Results of ANOVA comparing dwell time differences during FER trials

Within-Subjects Effects				
Variable	df	F	*p*	η_p^2
Emotion	4	0.86	.49	0.03
Emotion x Age Group	16	2.33	.01	0.23
Emotion x Sex	4	0.44	.78	0.01
Emotion x Age Group x Sex	16	0.99	.47	0.11
Error (Emotion)	124	69.87	<.001	0.69
AOI	1.69	0.49	.83	0.06
AOI x Age Group	6.75	0.84	.42	0.03
AOI x Sex	1.69	0.76	.62	0.09
AOI x Age Group x Sex	6.75	7.25	<.001	0.19
Error (AOI)	52.34	0.92	.60	0.11
Emotion x AOI	8.97	0.62	.78	0.02
Emotion x AOI x Age Group	35.90	1.01	.46	0.12
Emotion x AOI x Sex	8.97			
Emotion x AOI x Age Group x Sex	35.90			
Error (Emotion x AOI)	278.18			

Between-Subjects Effects				
Variable	df	F	*p*	η_p^2
Intercept	1	4032.76	<.001	0.99
Age Group	4	0.54	.71	0.07
Sex	1	0.02	.89	0.00
Age Group x Sex	4	0.20	.94	0.03
Error	31			

Note. ANOVA = Analysis of Variance, AOI = Area of Interest, FER = Facial Emotion Recognition

Table 19

Mean number of fixations on AOIs across sex and age groups during recognition trials for angry bodily expressions

AOI	7 years				8 years				9 years			
	Male		Female		Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Torso	3.70	1.32	3.25	0.35	3.29	0.98	2.67	1.13	3.54	0.53	3.67	0.74
Neck	0.00	0.00	0.25	0.35	0.17	0.41	0.00	0.00	0.00	0.00	0.00	0.00
Hands	2.00	0.94	1.63	0.88	1.21	0.58	1.00	1.09	0.79	0.60	1.42	1.01
Arms	1.90	0.52	1.75	0.00	0.96	0.43	1.33	0.29	1.92	0.88	2.42	1.25
Legs	1.50	0.75	1.88	0.88	2.54	1.29	2.33	0.29	1.83	0.56	1.83	0.61
Feet	0.20	0.27	0.00	0.00	0.33	0.26	0.42	0.52	0.38	0.41	0.50	0.76
Off Person	0.25	0.31	0.25	0.35	0.08	0.13	0.58	0.63	0.58	0.26	0.38	0.21

Table 20 (continued)

AOI	10 years				11 years			
	Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Torso	3.75	1.14	4.13	1.27	4.08	0.95	3.50	0.00
Neck	0.13	0.25	0.00	0.00	0.00	0.00	0.00	0.00
Hands	1.13	0.60	1.31	1.34	0.75	0.43	1.13	0.88
Arms	2.00	0.50	2.44	0.66	2.17	0.63	1.38	0.18
Legs	1.81	0.85	1.94	0.72	1.42	0.29	2.13	0.18
Feet	0.19	0.24	0.44	0.43	0.08	0.14	0.38	0.18
Off Person	0.38	0.25	0.50	0.20	0.08	0.14	0.38	0.18

Note. AOI = Area of Interest, SD = Standard Deviation

Table 20

Mean number of fixations on AOIs across sex and age groups during recognition trials for happy bodily expressions

AOI	7 years				8 years				9 years			
	Male		Female		Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Torso	4.00	0.64	2.00	0.00	3.00	1.19	2.83	0.52	3.67	0.58	3.54	0.89
Neck	0.00	0.00	0.00	0.00	0.08	0.20	0.00	0.00	0.08	0.20	0.00	0.00
Hands	1.80	1.05	2.00	1.06	1.29	0.66	0.92	0.52	1.29	0.71	1.71	1.70
Arms	2.50	0.75	1.25	0.35	1.54	1.09	1.75	1.09	1.83	0.65	2.67	1.33
Legs	1.85	0.55	1.75	1.06	1.63	0.52	2.50	0.66	1.67	0.66	2.04	0.87
Feet	0.20	0.11	0.00	0.00	0.33	0.47	0.67	0.52	0.42	0.41	0.17	0.30
Off Person	0.95	0.60	0.88	0.53	0.54	0.53	1.08	0.63	0.71	0.33	0.83	0.56

Table 21 (continued)

AOI	10 years				11 years			
	Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Torso	3.38	0.85	4.19	0.99	4.33	1.46	3.50	0.71
Neck	0.13	0.25	0.00	0.00	0.00	0.00	0.00	0.00
Hands	1.25	0.82	1.50	0.74	0.50	0.50	1.38	0.53
Arms	2.50	1.37	3.31	1.53	1.92	0.14	1.13	0.18
Legs	2.06	1.11	1.75	1.14	1.92	0.52	1.63	0.18
Feet	0.31	0.31	0.31	0.31	0.17	0.29	0.25	0.35
Off Person	0.44	0.24	0.88	0.66	0.58	0.38	0.50	0.35

Note. AOI = Area of Interest, SD = Standard Deviation

Table 21

Mean number of fixations on AOIs across sex and age groups during recognition trials for sad bodily expressions

AOI	7 years				8 years				9 years			
	Male		Female		Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Torso	3.25	0.85	2.38	1.24	2.79	0.78	1.58	1.01	2.42	0.80	3.00	1.16
Neck	0.00	0.00	0.00	0.00	0.08	0.20	0.00	0.00	0.00	0.00	0.00	0.00
Hands	1.00	0.88	1.25	0.71	0.71	0.49	1.25	0.90	1.00	0.35	1.50	1.01
Arms	0.30	0.33	1.25	0.71	0.29	0.29	0.33	0.14	0.92	1.04	0.58	0.54
Legs	3.65	1.11	3.63	1.24	3.71	1.34	3.83	0.88	3.08	0.77	4.29	1.95
Feet	0.20	0.27	0.00	0.00	0.25	0.27	0.42	0.14	0.25	0.32	0.21	0.33
Off Person	0.20	0.21	0.38	0.53	0.17	0.20	0.58	0.14	0.50	0.39	0.54	0.37

Table 22 (continued)

AOI	10 years				11 years			
	Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Torso	2.63	0.72	3.69	1.48	3.50	1.56	3.50	0.35
Neck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hands	0.81	0.52	1.00	0.79	0.75	0.43	1.00	1.06
Arms	0.25	0.20	0.31	0.31	0.25	0.25	0.50	0.00
Legs	4.50	1.02	4.44	1.53	2.83	0.72	4.25	2.12
Feet	0.44	0.72	0.56	0.66	0.08	0.14	0.50	0.71
Off Person	0.25	0.35	0.25	0.20	0.67	0.29	0.38	0.18

Note. AOI = Area of Interest, SD = Standard Deviation

Table 22

Mean number of fixations on AOIs across sex and age groups during recognition trials for fearful bodily expressions

AOI	7 years				8 years				9 years			
	Male		Female		Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Torso	3.05	0.82	2.25	0.71	2.50	0.74	3.00	0.90	3.29	0.51	3.54	1.35
Neck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.20
Hands	0.80	0.45	1.25	0.35	0.54	0.29	1.17	0.76	0.83	0.41	1.17	0.80
Arms	1.30	0.54	1.13	0.18	1.29	0.84	1.08	0.14	1.42	0.44	2.13	0.82
Legs	1.50	0.64	0.63	0.18	2.00	0.99	2.31	1.04	1.46	0.43	2.25	0.91
Feet	1.05	0.54	0.63	0.18	0.92	0.65	1.33	0.63	0.96	0.37	0.79	0.46
Off Person	0.08	0.05	0.05	0.07	0.08	0.04	0.12	0.04	0.09	0.08	0.05	0.05

Table 23 (continued)

AOI	10 years				11 years			
	Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Torso	3.50	0.91	3.13	0.63	3.00	0.66	2.50	0.35
Neck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hands	1.06	0.66	1.44	0.63	0.67	0.14	1.13	0.18
Arms	1.38	0.43	1.63	0.14	1.50	0.75	0.88	0.18
Legs	1.63	0.95	2.88	0.85	1.33	0.76	1.50	0.71
Feet	0.81	0.52	1.06	0.43	1.08	0.58	1.25	0.71
Off Person	0.03	0.04	0.04	0.04	0.04	0.04	0.12	0.12

Note. AOI = Area of Interest, SD = Standard Deviation

Table 23

Mean number of fixations on AOIs across sex and age groups during recognition trials for neutral bodily expressions

AOI	7 years				8 years				9 years			
	Male		Female		Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Torso	4.05	0.65	2.25	1.06	3.08	0.97	1.92	0.29	3.00	1.39	3.63	1.13
Neck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hands	0.85	0.84	1.50	2.12	0.71	0.46	0.83	0.52	0.50	0.27	0.88	0.68
Arms	0.30	0.33	1.25	0.71	0.38	0.34	0.00	0.00	0.38	0.49	0.29	0.49
Legs	3.60	0.76	3.75	2.47	3.50	0.95	4.33	0.29	4.00	1.50	4.21	0.70
Feet	0.75	0.35	0.63	0.88	0.13	0.21	0.67	0.29	0.25	0.32	0.33	0.49
Off Person	0.35	0.22	0.50	0.00	0.46	0.29	0.50	0.66	0.25	0.22	0.38	0.34

Table 24 (continued)

AOI	10 years				11 years			
	Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Torso	4.00	0.65	4.69	2.21	4.00	0.50	4.50	1.77
Neck	0.13	0.25	0.00	0.00	0.00	0.00	0.00	0.00
Hands	0.94	0.31	1.00	0.94	0.67	0.76	0.38	0.53
Arms	0.13	0.14	0.38	0.14	0.33	0.58	0.00	0.00
Legs	3.50	1.59	3.69	1.30	3.25	0.25	2.63	1.94
Feet	0.38	0.48	0.38	0.48	0.00	0.00	0.25	0.35
Off Person	0.31	0.24	0.50	0.20	0.42	0.38	0.38	0.53

Note. AOI = Area of Interest, SD = Standard Deviation

Table 24

Results of ANOVA comparing number of fixations during BER trials

Within-Subjects Effects				
Variable	df	F	*p*	η_p^2
Emotion	2.70	216.27	<.001	0.88
Emotion x Age Group	10.80	1.39	.20	0.15
Emotion x Sex	2.70	0.99	.39	0.03
Emotion x Age Group x Sex	10.80	0.56	.85	0.07
Error (Emotion)	119.09	57.16	<.001	0.65
AOI	6	0.93	.56	0.11
AOI x Age Group	24	0.75	.61	0.02
AOI x Sex	6	0.78	.76	0.09
AOI x Age Group x Sex	24	66.64	<.001	0.68
Error (AOI)	186	1.31	.13	0.15
Emotion x AOI	7.88	0.62	.76	0.02
Emotion x AOI x Age Group	31.53	1.00	.48	0.11
Emotion x AOI x Sex	7.88			
Emotion x AOI x Age Group x Sex	31.53			
Error (Emotion x AOI)	244.37			

Between-Subjects Effects				
Variable	df	F	*p*	η_p^2
Intercept	1	1560.52	<.001	0.98
Age Group	4	1.63	.19	0.17
Sex	1	0.87	.36	0.03
Age Group x Sex	4	1.31	.29	0.15
Error	31			

Note. ANOVA = Analysis of Variance, AOI = Area of Interest, BER = Bodily Emotion Recognition

Table 25

Mean number of fixations on AOIs across sex and age groups during recognition trials for angry facial expressions

AOI	7 years				8 years				9 years			
	Male		Female		Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Eyes	3.90	2.38	1.50	0.00	3.00	1.18	2.50	0.87	2.42	1.83	3.33	1.51
Nose	3.40	1.52	2.25	1.06	3.92	0.66	3.67	1.26	2.50	1.38	3.83	0.75
Mouth	0.80	0.57	2.25	0.35	1.83	1.21	1.67	0.29	1.83	0.93	1.25	0.82
Other Face	1.40	1.52	2.00	0.00	1.33	0.68	1.33	0.76	1.83	0.82	2.08	1.28
Hair	0.20	0.45	0.25	0.35	0.00	0.00	0.00	0.00	0.17	0.41	0.33	0.61
Neck	0.00	0.00	0.25	0.35	0.17	0.41	0.00	0.00	0.00	0.00	0.00	0.00
Off Face	0.00	0.00	0.00	0.00	0.17	0.26	0.17	0.29	0.33	0.61	0.00	0.00

Table 26 (continued)

AOI	10 years				11 years			
	Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Eyes	2.75	1.94	5.13	0.75	3.33	1.53	2.50	2.12
Nose	2.88	0.25	2.38	0.75	3.00	0.50	3.75	3.18
Mouth	1.25	0.29	1.38	1.03	0.50	0.50	1.75	0.35
Other Face	1.63	1.11	1.50	0.58	1.17	0.29	1.50	0.71
Hair	0.00	0.00	0.00	0.00	0.33	0.58	0.00	0.00
Neck	0.13	0.25	0.00	0.00	0.00	0.00	0.00	0.00
Off Face	0.13	0.25	0.38	0.75	0.00	0.00	0.00	0.00

Note. AOI = Area of Interest, SD = Standard Deviation

Table 26

Mean number of fixations on AOIs across sex and age groups during recognition trials for happy facial expressions

AOI	7 years				8 years				9 years			
	Male		Female		Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Eyes	2.70	1.25	2.00	2.12	3.00	1.95	2.17	2.02	1.17	0.75	3.25	1.64
Nose	2.60	0.82	2.25	1.77	3.33	0.98	2.67	1.53	2.92	1.02	3.25	0.69
Mouth	2.10	1.19	2.75	0.35	3.50	1.67	2.83	2.75	3.75	1.04	1.50	1.38
Other Face	1.80	1.10	2.25	1.06	1.42	1.59	0.83	1.44	1.42	0.80	1.42	0.80
Hair	0.40	0.55	0.50	0.71	0.17	0.26	0.33	0.58	0.33	0.82	0.25	0.42
Neck	0.00	0.00	0.00	0.00	0.08	0.20	0.00	0.00	0.08	0.20	0.00	0.00
Off Face	0.40	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 27 (continued)

AOI	10 years				11 years			
	Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Eyes	3.13	0.75	4.25	3.23	2.83	2.84	2.75	0.35
Nose	3.38	2.17	2.13	0.48	2.33	0.76	3.00	0.71
Mouth	2.00	0.82	1.00	0.41	2.67	1.53	3.75	0.35
Other Face	0.88	0.85	0.75	1.19	0.67	0.29	1.75	0.35
Hair	0.25	0.50	0.13	0.25	0.33	0.29	1.00	1.41
Neck	0.13	0.25	0.00	0.00	0.00	0.00	0.00	0.00
Off Face	0.00	0.00	0.00	0.00	0.33	0.29	0.00	0.00

Note. AOI = Area of Interest, SD = Standard Deviation

Table 27

Mean number of fixations on AOIs across sex and age groups during recognition trials for sad facial expressions

AOI	7 years				8 years				9 years			
	Male		Female		Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Eyes	5.10	2.41	4.75	2.47	3.33	2.16	4.17	3.21	2.50	1.00	4.92	1.66
Nose	3.00	1.90	1.25	1.06	3.75	1.04	2.33	0.58	4.17	1.91	2.83	1.08
Mouth	0.70	0.84	1.50	0.71	1.92	1.77	1.00	1.32	2.25	1.08	0.50	0.55
Other Face	1.50	1.73	2.50	1.41	1.83	1.25	1.83	1.44	1.83	1.13	1.92	1.16
Hair	0.40	0.22	0.50	0.71	0.00	0.00	0.00	0.00	0.17	0.26	0.42	0.80
Neck	0.00	0.00	0.00	0.00	0.08	0.20	0.00	0.00	0.00	0.00	0.00	0.00
Off Face	0.10	0.22	0.00	0.00	0.25	0.27	0.00	0.00	0.08	0.20	0.00	0.00

Table 28 (continued)

AOI	10 years				11 years			
	Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Eyes	2.63	1.03	5.63	4.07	4.67	3.62	4.25	1.06
Nose	3.50	0.41	2.63	1.44	2.17	1.53	4.25	1.77
Mouth	0.88	0.63	0.88	0.85	1.00	1.00	2.25	1.06
Other Face	1.63	0.85	0.88	0.85	1.17	0.76	0.75	0.35
Hair	0.00	0.00	0.00	0.00	0.17	0.29	0.00	0.00
Neck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Off Face	0.25	0.50	0.13	0.25	0.00	0.00	0.00	0.00

Note. AOI = Area of Interest, SD = Standard Deviation

Table 28

Mean number of fixations on AOIs across sex and age groups during recognition trials for fearful facial expressions

AOI	7 years				8 years				9 years			
	Male		Female		Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Eyes	5.50	3.20	6.00	0.71	4.17	2.42	4.83	3.33	3.42	2.18	4.25	2.12
Nose	3.00	1.27	2.50	0.71	2.83	0.93	2.50	0.00	3.67	1.44	4.08	1.39
Mouth	1.20	1.04	1.75	1.77	1.33	1.40	0.83	0.76	1.67	0.82	1.42	1.20
Other Face	1.70	1.04	1.75	1.06	1.42	0.74	1.67	1.61	1.08	0.97	2.17	1.08
Hair	0.20	0.27	0.25	0.35	0.00	0.00	0.17	0.29	0.08	0.20	0.08	0.20
Neck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.20
Off Face	0.00	0.00	0.00	0.00	0.08	0.20	0.17	0.29	0.08	0.20	0.00	0.00

Table 29 (continued).

AOI	10 years				11 years			
	Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Eyes	3.50	2.42	7.50	0.71	5.50	3.00	4.50	2.12
Nose	3.75	1.55	3.00	1.15	2.67	0.76	2.50	1.41
Mouth	1.50	1.29	1.25	0.96	0.17	0.29	1.50	0.00
Other Face	1.00	1.35	1.38	0.63	0.67	1.15	1.00	0.71
Hair	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Neck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Off Face	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note. AOI = Area of Interest, SD = Standard Deviation

Table 29

Mean number of fixations on AOIs across sex and age groups during recognition trials for neutral facial expressions

AOI	7 years				8 years				9 years			
	Male		Female		Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Eyes	4.60	1.08	4.00	0.00	3.50	1.79	2.67	0.76	2.75	2.25	3.92	1.72
Nose	3.70	1.04	3.00	1.41	3.33	0.41	2.50	0.50	3.50	1.92	4.42	1.16
Mouth	1.60	0.96	1.75	1.06	1.50	1.14	1.33	1.26	1.58	1.50	2.00	1.30
Other Face	0.70	0.27	2.00	2.12	0.67	0.75	1.67	1.61	1.00	0.84	1.25	1.54
Hair	0.20	0.27	0.00	0.00	0.08	0.20	1.17	1.61	0.25	0.42	0.50	0.84
Neck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Off Face	0.10	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.20	0.00	0.00

Table 30 (continued)

AOI	10 years				11 years			
	Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Eyes	2.88	2.29	6.25	2.40	2.00	1.00	4.00	0.71
Nose	4.00	0.58	3.38	1.03	3.00	2.00	2.25	1.06
Mouth	1.63	1.31	1.38	0.63	0.17	0.29	2.25	1.77
Other Face	1.00	0.41	1.13	0.48	3.67	2.57	0.75	0.35
Hair	0.00	0.00	0.25	0.50	0.17	0.29	0.25	0.35
Neck	0.13	0.25	0.00	0.00	0.00	0.00	0.00	0.00
Off Face	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note. AOI = Area of Interest, SD = Standard Deviation

Table 30

Results of ANOVA comparing number of fixations during FER trials

Within-Subjects Effects				
Variable	df	F	*p*	η_p^2
Emotion	1.46	253.41	<.001	0.89
Emotion x Age Group	5.85	1.13	.36	0.13
Emotion x Sex	1.46	1.68	.20	0.05
Emotion x Age Group x Sex	5.85	2.16	.07	0.22
Error (Emotion)	45.34	16.45	<.001	0.35
AOI	3.39	0.87	.60	0.10
AOI x Age Group	13.57	0.70	.57	0.02
AOI x Sex	3.39	0.90	.56	0.10
AOI x Age Group x Sex	13.57	10.07	<.001	0.25
Error (AOI)	105.13	0.82	.73	0.10
Emotion x AOI	7.07	0.91	.50	0.03
Emotion x AOI x Age Group	28.29	0.93	.58	0.11
Emotion x AOI x Sex	7.07			
Emotion x AOI x Age Group x Sex	28.29			
Error (Emotion x AOI)	219.27			

Between-Subjects Effects				
Variable	df	F	*p*	η_p^2
Intercept	1	2802.04	<.001	0.99
Age Group	4	0.58	.68	0.07
Sex	1	2.64	.11	0.08
Age Group x Sex	4	2.03	.12	0.21
Error	31			

Note. ANOVA = Analysis of Variance, AOI = Area of Interest, FER = Facial Emotion Recognition

Table 31

Mean raw score across parent- and child-ratings of social-emotional measures

Variable	N	Mean	SD
Children's Social Emotional Measure			
Parent-reported Scales			
Persistence	38	2.895	0.58
Self-control	38	2.991	0.49
Social Competence	38	3.228	0.56
Self-Reported Scales			
Self-control	41	3.034	0.43
Academic Self-efficacy	41	3.317	0.65
Persistence	41	3.585	0.41
Mastery Orientation	41	3.098	0.73
CBCL			
Anxious-Depressed	38	16.79	3.41
Withdrawn-Depressed	38	8.97	1.24
Somatic Complaints	38	12.45	1.69
Social Problems	38	13.16	2.02
Thought Problems	37	16.97	2.30
Attention Problems	38	14.66	3.45
Rule Breaking Behavior	38	18.21	1.14
Aggressive Behavior	38	22.58	4.00
Affective Problems	38	14.63	1.75
Anxiety Problems	38	8.13	2.17
Somatic Problems	38	8.11	1.50
ADHD	38	10.79	2.63
Oppositional Defiant Problems	38	7.42	1.88
Conduct Problems	38	17.87	1.12
Sluggish Cognitive Temp	38	4.89	1.01

Note. ADHD = Attention-Deficit/Hyperactivity Disorder,

CBCL = Child Behavior Checklist, SD = Standard Deviation