Alexithymia and Atypical Facial Expressions in Individuals with Autism Spectrum Disorders

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The author, whose name appears on the title page of this work, has obtained, for the research described in this work, either:

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Abstract

This dissertation research sought to determine in what ways, and in what contexts, emotional facial expressions are atypical in the Autism Spectrum Disorder (ASD) population, and to investigate the specific role that alexithymia—a condition characterized by difficulties identifying and describing one's feelings—may relate to facial expression production abilities in individuals with and without ASD. Results of a meta-analysis showed that on average, individuals with ASD display facial expressions less frequently and are less likely to share facial expressions with others in naturalistic settings or automatically mimic the expressions of real faces or face stimuli in comparison to non-ASD comparison groups. Their facial expressions are rated as more awkward or unusual in appearance, sometimes making it difficult for observers to identify what emotion is being expressed. However, across studies, participants with ASD do not express emotions less intensely, nor do they respond more slowly to emotion-eliciting stimuli. Age, intellectual functioning of ASD participants, and methodological features of the study, significantly moderated the strength of effect sizes. A second study examined *spontaneous* facial production in response to emotionally arousing videos in children with and without ASD. Results showed that alexithymia, but not ASD traits, was negatively correlated with spontaneous production of negative facial expressions. A similar pattern of results was found in a third study, such that alexithymia and depression were associated with less spontaneous emotional expression during tasks that required typically developing undergraduates to watch emotional video clips or tell emotional stories about their personal lives. In a separate task in which participants were instructed to pose emotional facial expressions, it was hypothesized that reduced voluntary expression accuracy would be more strongly related to ASD traits than alexithymia or depression, although support for this prediction was mixed. Results provide partial support for the suggestion that reduced spontaneous expression and reduced voluntary expression accuracy have distinct correlates. I argue that the alexithymia construct deserves significantly more research and clinical attention within the ASD population.

Keywords: Alexithymia; Autism; Facial Expressions; Emotion

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Glossary

Alexithymia	Difficulties identifying and describing one's own feelings, and an externally-oriented thinking style with limited self-reflected thought.
Involuntary expression	Automatic facial expressions that are not consciously controlled, that may result from affective arousal or mimicry processes. In this dissertation, involuntary expression is an 'umbrella' term that encompasses both *spontaneous expression* and *automatic mimicry*.
Voluntary expression	Facial expressions that are intentionally displayed or 'posed' in response to various experimental instructions (e.g., "How do you look when you're sad?"), or during social interactions (e.g., smiling at an acquaintance).
Spontaneous expression	A type of involuntary facial expression that is the physiological consequence of internal affective arousal.
Automatic Mimicry*	A type of involuntary facial expression that results from viewing and then replicating a facial expression stimulus (could be a static image, video, or real person).
Facial Imitation*	Voluntary production of facial expression that replicates a facial expression stimulus the observer is viewing (could be a static image, video, or real person).
Suppression	Conscious inhibition of emotional expression.
Repression	Subconscious inhibition of emotional expression.
Social-emotional reciprocity	Sharing of interests, emotions and affect, to augment the fluidity of social exchanges.
Basic emotions	Emotions that are not culturally constructed but biologically engrained, serving adaptive value to humans. These emotions are generally considered to be anger, fear, disgust, sadness, surprise and joy, although there is some theoretical disagreement as to which emotions are basic.
Facial Action Coding System (FACS)	A taxonomy of human facial movements, that in various combination represent different emotional facial expressions.
Mirror Neuron System (MNS)	A neural system that is thought to serve as an important bridge between visual processing areas and the motor cortex, such that the same neurons are activated both when seeing an action and performing that action. The MNS is thought to play a critical role in automatic mimicry and imitation of facial expressions and other motor actions.
Autonomic Nervous System (ANS)	The part of the nervous system responsible for control of internal bodily functions that are not consciously directed, such as breathing, heartbeat, and digestive processes.
Central Nervous System (CNS)	The system of nerve tissues that controls the activities of the body. In humans it comprises the brain and spinal cord.
Motor System	The part of the central nervous system that is involved with movement. It consists of the pyramidal and extrapyramidal system.

Extrapyramidal System	The part of the motor system that is responsible for involuntary motor actions.
Pyramidal System	The part of the motor system that is responsible for voluntary motor actions.
Interoception	The perception of the physiological condition of the body, including hunger, temperature, pain and heart rate (among other things). Interoception represents an important connection between the ANS and CNS, such that the CNS must accurately detect and discriminate ANS signals so that the CNS can subsequently regulate bodily processes.
Interoceptive Perception	Conscious and subconscious processing of a variety of bodily states, neural activity, and ongoing cognition, necessary for maintaining homeostasis
Interoceptive Sensitivity	Accurate detection and discrimination of interoceptive signals on explicit interoception tasks such as the Heartbeat Tracking Task.
Proprioception	The unconscious perception of spatial orientation and kinesthetic information from the body to allow movement and provide a sense of agency.
Homeostasis	The tendency of the body to seek and maintain a condition of balance or equilibrium within its internal environment.
Mentalization	The ability to understand the mental state of oneself or others that underlies observable behaviour. Through mentalization, we perceive and interpret human behaviour in terms of intentional mental states (e.g., needs, desires, feelings, beliefs, goals).

Note. *The terms ‘imitation’ and ‘mimicry’ appear to be used interchangeably in the extant literature. For the purpose of clarity in this dissertation, mimicry refers to involuntary displays while imitation refers to voluntary displays.

Chapter 1.

General Introduction

1.1. Autism Spectrum Disorder

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder that is diagnosed as early as two years old, with symptoms persisting throughout one's lifespan (APA, 2013). ASD is characterized by the presence of multiple symptoms from each of two broad sets of criteria: 1) deficits in social communication and social interactions, and 2) restricted, repetitive patterns of behavior (RRBs). These broad sets of criteria are further broken into subcategories. An ASD diagnosis requires the presence of all three of the following deficits in social communication and social interaction: 1) deficits in social-emotional reciprocity, 2) deficits in nonverbal communicative behaviors used for social interaction, and 3) deficits in developing, maintaining, and understanding relationships. These deficits range from unusual expression of nonverbal cues, (such as sharing of affect via facial expression, vocal tone, or body language), as well as difficulties inferring others' nonverbal cues relating to emotion, perspectives and intentions. These difficulties extend to problems understanding the nuances of verbal conversation, which adversely affect one's ability to initiate social interactions or respond to others' initiations, to appropriately modify one's behavior according to social context, and to form and maintain meaningful relationships. Roughly 40% of people with ASD have comorbid intellectual disability (CDC, 2012) which significantly impacts verbal communication abilities and other social skills, and a smaller subset of individuals have severe communication difficulties that may necessitate the use of alternative and augmentative communication devices. However, even individuals with ASD who have average or above average verbal intelligence may have difficulties constructing implicit meanings from the speech of others that varies according to social context, integrating nonverbal aspects of social communication with verbal exchanges, and with awareness of how to communicate in socially appropriate ways (e.g., dominating conversation, or problems with the timing of back-and-forth conversation; Kim, Paul, Tager-Flusberg & Lord, 2014).

To receive an ASD diagnosis, individuals must also meet two of four criteria within the following RRB category: 1) stereotyped or repetitive motor movements, 2) insistence on sameness/inflexible routines or ritualized patterns of behavior, 3) highly restricted or fixated interests with abnormal intensity, and/or 4) hyper- or hypo-reactivity to sensory input or unusual fixation of sensory information. The RRB category includes stereotyped or repetitive motor movements that could range from echolalia, motor stereotypies such as body-rocking and hand-flapping, or unusual, repetitive use of toys (e.g., obsessively spinning wheels of a toy car) in the absence of imaginative play (APA, 2013). RRBs also extend to insistence on sameness, inflexible adherence to routines (e.g., restricted and repetitive diets and rigid schedules that may cause significant distress when deviated), rigid thinking patterns, and limited and intense interest in certain objects, games, or topics. The RRB criteria also includes unusual processing of sensory stimuli that range from hyper- or hypo-reactive responses to sensory input. This may include indifference to pain or temperature, adverse response to certain sounds and textures, difficulties integrating multi-modal sensory inputs, or preoccupation and fascination with certain smells, lights or motion (APA, 2013). While knowing the criteria for ASD diagnosis is pertinent for understanding the disorder as a whole, the present research will focus on the first set of criteria discussed related to social communication and social interaction difficulties, especially in regard to the atypical use of nonverbal communication.

1.2. Overview and Rationale of the Present Dissertation Research

In the field of ASD research there is a burgeoning interest in *alexithymia*—a condition characterized by difficulties identifying and describing one’s own feelings (Kooiman, Spinhoven, & Trijsburg, 2002; Nemiah, Freybarger, & Sifneos, 1976; Taylor & Bagby, 2000, 2004a,b). This interest stems from findings of significantly heightened rates of alexithymia in the ASD population compared to the general population (Hill, Berthoz, & Frith, 2004), and how these heightened rates of alexithymia may contribute to the broader social-emotional characteristics of ASD. A lack of awareness and understanding of one's own emotions as a result of alexithymia may a) inhibit one's ability to reflect on the cause of one's negative emotions making it difficult to remediate life problems, b) make it difficult to regulate one's emotions which could result in emotional outbursts in the short-term or chronic anxiety and depression in the long-term, and c) may inhibit one's ability to share and communicate emotions with others which may detract from one's ability to form and maintain relationships (Goleman, 2006; Taylor & Bagby, 2004a; Vanheule, Desmet, Meganck, & Bogaerts, 2007; Way et al., 2010).

As will be described in Section 1.5, several studies have demonstrated a relationship between alexithymia and reduced nonverbal displays of emotions (e.g., reduced facial expressions) such that individuals who have difficulties understanding emotions in themselves (i.e., alexithymia), are less likely to communicate emotions nonverbally via facial expressions (McDonald & Prkachin, 1990; Rasting, Brosig &, Beutel, 2005; Troisi, Delle Chiaie, Russo, Russo, Mosco, & Pasini, 1996; Wagner & Lee, 2008). This paucity of facial expressions associated with alexithymia exists despite a predominance of evidence that individuals with high levels of alexithymia experience emotions physiologically at normal or even heightened levels, although research on this topic is mixed (see, Taylor, 2000, for a review). While the association between alexithymia and reduced facial expression production is not particularly well understood, some researchers have speculated that alexithymia is associated with a general disposition towards *suppressing* emotional expression (i.e., consciously inhibiting one's facial displays), or *repressing* emotional expression (i.e., subconsciously inhibiting one's facial displays; McDonald & Prkachin, 1990; Rasting et al., 2005; Troisi et al., 1996; Wagner & Lee, 2008).

Despite the heightened occurrence of alexithymia, and atypical use of facial expressions in the ASD population (APA, 2013), this relationship has not been tested in ASD. The focus of this dissertation was to determine in what ways, and in what contexts, facial expressions are atypical in the ASD population in relation to typically developing (TD) or non-ASD clinical comparisons (Chapter 2), to investigate the potential relationship between alexithymia and atypical facial expressions in ASD (Chapter 3), and to determine how alexithymia, ASD traits and depression may be related to various types of facial expressions in the general population (Chapter 4). While a primary interest of Chapters 3 and 4 was to examine the relations between alexithymia and nonverbal expression, the role of depression was also considered because depression is associated with flat affect (Sobin & Sackeim, 1997; Ulrich & Harms, 1985).

Throughout the remainder of this chapter, I will describe the 'alexithymia hypothesis' proposed by Bird and Cook (2013) which posits that several social-emotional deficits in ASD may be explained by heightened rates of alexithymia, followed by a description of the extant literature on alexithymia and facial expressions in non-ASD populations. Next, I will review the theoretical perspectives and empirical evidence describing what is known about normative facial expression development, the social-emotional functions that facial expressions serve, and how facial expressions differ in ASD. Following this review, I will introduce each of the three empirical studies presented in this dissertation. This research advances knowledge about how people with ASD may produce facial expressions differently than non-ASD populations and provide a more nuanced interpretation of how alexithymia and ASD traits relate to different types of facial expression production abilities in the ASD population and in the general population.

1.3. Alexithymia

The term 'alexithymia' was coined by a psychiatrist named Peter Sifneos (1973) to characterize some of his patients who seemingly lacked the ability to access, describe, and understand the cause of their innermost feelings, which proved to be a major detriment to the effectiveness of psychotherapy. Based on early descriptions of alexithymia that emerged from therapeutic interviews and clinical assessments, the first prominent clinician-researchers to systematically investigate alexithymia arrived at a theoretical consensus of what the alexithymia construct entails: a) difficulties identifying and describing one's emotions, b) lack of awareness that some bodily sensations are due to emotions that may result in misattributing affective arousal to physical symptoms, c) an “externally-oriented thinking style” that involves focus on external realities with limited self-reflective thought towards inner experience, and d) limited imagination and fantasy life (Kooiman et al., 2002; Nemiah et al., 1976; Taylor & Bagby, 2000, 2004a,b). Alexithymia is not listed in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) as an independent disorder. However, it is associated with several psychopathologies including personality disorders, eating disorders, substance abuse disorders, depression, anxiety, post-traumatic stress disorder, schizophrenia and ASD; and physical disorders including obesity, diabetes, and multiple sclerosis (see Bird & Cook, 2013; Murphy, Brewer, Catmur, & Bird, 2017 for reviews). Alexithymia may have a particularly strong comorbidity with ASD (Bird & Cook, 2013). The extent to which alexithymia is present in ASD is in need of an epidemiological study, although one study estimated that ‘severe alexithymia’ occurs in approximately 50% of the ASD population (Hill et al., 2004), compared to approximately 13% in the general population (Salminen, Saarijärvi, Äärelä, Toikka, & Kauhanen, 1999), with higher prevalence in men (17%) than in women (10%; Salminen et al., 1999).

1.4. The ‘Alexithymia Hypothesis’

One of the biggest challenges facing researchers who study ASD is the wide phenotypic heterogeneity that exists within this population. Despite several decades of avid research interest in ASD, researchers have failed to find a specific behavioral symptom, biomarker or gene that reliably predicts an ASD diagnosis (Silberman, 2015). As is the case with many disorders and psychopathologies, there are likely multiple developmental pathways to ASD that arise from a complex array of genetic and environmental risk factors, and neurodevelopmental vulnerabilities (Jones, Gliga, Bedford, Charman, & Johnson, 2014). ASD may be best conceptualized as a cluster of symptoms (Mundy, Sigman, & Kasari, 1994) that vary substantially within the ASD population. An unfortunate result of this heterogeneity is a rather inconsistent pattern of results that emerge in many bodies of ASD research that limits our ability to draw definitive conclusions from an ever-growing evidence base. However, by carefully characterizing individual and group level differences, researchers can use this heterogeneity to understand how individual differences may account for equivocal research findings.

One critical characteristic that may account for some of this heterogeneity is *alexithymia*, which has generated increasing interest from ASD researchers only within the last 15 years. Recently, the ‘alexithymia hypothesis’ was developed by Bird and Cook (2013), which posits that a cluster of social-emotional impairments (e.g., deficits in empathy, emotion recognition, eye fixation, and interoception) are more common in the ASD population than in the TD population—but these impairments are not necessarily universal among all people with ASD and they may be attributable more to individual differences in alexithymia than to deficits associated with ASD. Essentially, Bird and Cook’s argument is that such social-emotional impairments should not be categorized within the core criteria of ASD relating to social communication and social interaction deficits, and that the occurrence of these impairments are due to co-occurring alexithymia.

The hypothesis has been tested in multiple ways. Some studies (e.g., Cook, Brewer, Shah & Bird, 2013; Shah, Hall, Catmur, & bird, 2016) have matched ASD and comparison groups on levels of alexithymia to examine group differences in various social-emotional impairments. In representative samples of ASD and TD comparison groups, the ASD group would be expected to have higher levels of alexithymia (Bird & Cook, 2013). Thus, by artificially matching groups on levels of alexithymia, the presence or absence of group differences helps to clarify which social-emotional impairments are associated with ASD, and which are associated with alexithymia. The alexithymia hypothesis has also been examined using simple correlational techniques or by pitting continuous measures of alexithymia and ASD traits against each other in multiple regression analyses to examine the independent contributions of each independent variable when predicting variance in various dependent variables of interest.

A handful of studies to date have empirically tested the alexithymia hypothesis using the methods described in the previous paragraph (Bird, Silani, Brindley, White, Frith, & Singer, 2010; Bird, Press & Richardson, 2011; Cook et al., 2013; Shah, et al., 2016). In one of these studies, Cook et al. (2013) demonstrated that when ASD and TD comparison groups were matched on levels of alexithymia, age, gender and intelligence, no group differences were observed in the precision with which participants correctly judged emotional facial expressions. Further correlational analyses revealed that alexithymia, but not ASD traits, predicted individual differences in emotion recognition accuracy. Importantly, these findings may help to explain the large heterogeneity in findings from emotion recognition studies in the ASD literature (see Harms, Martin & Wallace, 2010 for a review). Whereas some studies Harms et al. (2010) reviewed found ASD deficits and some did not, it is possible that varying levels of alexithymia in various samples partially contributed to the discrepant findings in the literature (Cook et al., 2013).

In another examination of the alexithymia hypothesis, Bird et al. (2011) sought to explore the role alexithymia may play in social attention abnormalities in ASD, as evidence for reduced eye-fixation in ASD is inconsistent (see Buitelaar, 1995, for a review). Bird et al. (2011) showed participants with ASD video clips from a popular drama television show depicting characters engaged in dramatic social-emotional interactions, as well as clips of a newscaster delivering news directly into the camera (to simulate direct eye-gaze), while their eye movements were recorded by an eye-tracker. Whereas there was no TD comparison group as in other studies testing the alexithymia hypothesis, results showed that ASD symptom severity was negatively correlated with attention to faces when watching the video clips yet only higher levels of alexithymia (but not ASD symptom severity) predicted reduced eye-fixation.

In a separate study, Bird et al. (2010) utilized an "empathy for pain" paradigm that involved showing participants with and without ASD video images of loved ones experiencing painful electrical shocks. This study found that activity in anterior insula—brain networks implicated in the perception of internal bodily cues and subjective feeling states (Saarela et al., 2007; Singer, Critchley, & Preuschoff, 2009)—was correlated with alexithymia, but not ASD traits in both groups. In addition, when controlling for group differences in alexithymia, no group differences in anterior insula activity were observed. Importantly, the video did not show facial or other affect cues, suggesting that the empathic processes in this study did not rely on low-level perceptual processing. Thus, this study demonstrates the important role that select brain areas responsible for perception of internal bodily cues (such as affective arousal) underlie both alexithymia and empathic processes. In addition, this study complements research with TD participants demonstrating correlations between alexithymia, activity in anterior insula, and self-reported empathy (Silani, Bird, Brindley, Singer, Frith, & Frith, 2008). In sum, these results indicate that empathy deficits observed in ASD (e.g., Smith, 2009), when present, may be due to co-occurring alexithymia.

Quattrocki and Friston (2014) recently proposed a developmental model of ASD which suggests that due to a dysfunctional oxytocin system, deficits in *interoception*—defined as the ability to perceive and regulate internal bodily processes to maintain homeostasis—may be responsible for a wide variety of language, social communication, sensory, autonomic, motor, behavioral and cognitive abnormalities observed in ASD. In response to Quattrocki and Friston's (2014) article, Brewer, Happé, Cook, and Bird (2015) suggested that the evidence more strongly points to the likelihood that interoceptive deficits underlie *alexithymia*, and not ASD. This explanation stems in part from the perspective that alexithymia signifies one aspect of interoceptive failure—difficulties perceiving and discriminating internal physiological cues of affect. To investigate the complex relations between ASD, alexithymia and interoception, Shah and colleagues' (2016) second experiment sought to directly test Brewer et al.'s (2015) assertion that interoception underlies alexithymia, and not ASD. Interoceptive sensitivity was measured using the well-validated Heartbeat Tracking task—a task that requires participants to count their heartbeats over varying time intervals, which are then compared to the actual number of heartbeats in that interval as measured by an objective pulsometer (Schandry, 1981). In this study, adults with ASD and a TD comparison group were matched on levels of alexithymia. As the authors predicted, no group differences in interoceptive sensitivity were observed, indicating interoceptive deficits were not associated with ASD diagnosis in this sample. Additional analyses indicated that higher alexithymia was strongly and negatively correlated with interoceptive sensitivity across both groups ($r = -.64$, $p < .01$), whereas ASD symptom severity was not significantly correlated with interoceptive sensitivity. These findings suggest that, when observed, interoceptive impairments in ASD are associated with alexithymia. Therefore, findings from previous research demonstrating impaired interoceptive sensitivity in ASD (Fiene & Brownlow, 2015; Garfinkel, Tiley, O'Keeffe, Harrison, Seth, & Critchley, 2016; cf, Schauder, Mash, Bryant, & Cascio, 2015) may be explained by heightened levels of alexithymia in the ASD population (Hill et al., 2004) and interoceptive deficits may not be directly related to ASD (Brewer, et al., 2015; Shah et al., 2016).

Although the research in this area is still burgeoning, the evidence is compelling; some of the social-emotional impairments that are typically considered features of ASD may be explained by co-occurring alexithymia. One characteristic of ASD that has yet to be examined in relation to the alexithymia hypothesis is nonverbal expression of affect. As will be described in more detail in section 1.7, individuals with ASD are generally less facially expressive, and are less likely to reciprocate others' emotional facial expressions (APA, 2013). However, the extent to which alexithymia is associated with atypical facial expressions in ASD has not been investigated.

1.5. Extant Literature on Alexithymia and Nonverbal Emotional Expression

Based on observations from his own psychotherapeutic practices, Krystal (1979) may have been the first to describe alexithymia as being associated with a paucity of facial expressions, although this relationship was not empirically tested until later. Some such empirical studies have supported Krystal's (1979) initial observations finding inverse correlations such that higher levels of alexithymia are associated with less nonverbal displays of affect (McDonald & Prkachin, 1990; Rasting, et al., 2005; Troisi, et al., 1996; Wagner & Lee, 2008), while other studies have found no association (Luminet, Rimé, Bagby, & Taylor, 2004; Roedema & Simons, 1999).

Wagner and Lee (2008) instructed a sample of TD adult women to describe past positive and negative experiences for 90 seconds each. Participants were video-recorded while they told their stories, and the salience of their facial expressions, as well as how much emotional language they used, were subsequently subjectively rated by raters using a Likert Scale format. Providing compelling support for their predictions, they found that negative verbal emotional expression and facial expression (but not positive expression) was significantly and negatively correlated with alexithymia as measured by the Toronto Alexithymia Scale (TAS-20; Bagby, Parker &, Taylor, 1994) as participants told a negative story. Similarly, positive expression (but not negative expression) was significantly and negatively correlated with alexithymia while participants told a positive story. The authors suggested that alexithymia is associated with a dispositional tendency towards inhibiting verbal and nonverbal emotional expression.

McDonald and Prkachin (1990) examined facial expression production in undergraduate men categorized as being alexithymic or non-alexithymic based on cut-off scores of a once common measure of alexithymia—the Schalling-Sifneos Personality Scale (Apfel & Sifneos, 1979). In one task, participants were shown pleasant images (e.g., a sunset) or unpleasant images (e.g., depictions of human suffering) while participants' facial expressions in response to the images were covertly recorded. In a separate task, participants viewed images of men modeling various emotional expressions and were instructed to imitate those expressions. Facial expressions of both tasks were coded by trained raters based on intensity of expression and what emotion was being expressed. Results showed no overall group differences on the intensity of posed expressions between the alexithymic and non-alexithymic groups, but that expressions in response to unpleasant (but not pleasant) images were significantly less intense and less interpretable as rated by the judges. The authors concluded that alexithymia is associated with less dispositional emotional expressiveness, but not an *inability* to express emotions based on the finding that the alexithymic group posed expressions with similar intensity as the non-alexithymic group when they were prompted to imitate facial expression images. It should be cautioned, that it is unclear how much conceptual overlap there is between the Schalling-Sifneos Personal Scale and other more commonly used measures like the TAS-20 to measure alexithymia.

Rasting et al. (2005) explored the relationship between alexithymia and facial expression production in a sample of in-patient adults taking part in a 4-week psychodynamically oriented in-patient crisis intervention. Data were analyzed among a subset of participants who agreed to have their initial interview with a psychotherapist videotaped and to complete a questionnaire battery including the German version of the TAS-26 (Kupfer, Brosig, & Brähler, 2000). Most patients in this study suffered from anxiety disorders, while others were diagnosed with depression, somatoform disorders or personality disorders. The dyadic interviews were subsequently analyzed using the EmFACS facial coding system (Friesen & Ekman, 1984). The researchers categorized facial expressions as “hedonic” (representing positive affect), “aggressive” (representing anger, disgust or contempt), or “submissive” (representing sadness). Results showed that alexithymia in this clinical sample was significantly associated with less aggressive affect, but not significantly associated with hedonic or submissive affect. The authors concluded that alexithymia in a clinical sample is not necessarily associated with a general deficiency in displaying facial expressions but is associated with an interpersonal style that aims to avoid conflict by suppressing or repressing facial displays that could lead to or exacerbate conflict.

While suppressing facial displays may serve short term goals of mitigating the possibility of interpersonal conflict, suppression may result in subsequent adverse consequences of increased anxiety and physiological discomfort. Troisi et al. (1996) tested the relationship between alexithymia and a variety of nonverbal behaviors including facial expressions in a sample of young adults with no medical or psychiatric disorders. During a psychiatric interview, participants’ behavior was scored with a taxonomy of ethological nonverbal behavior patterns (Grant, 1968) consisting of 37 behavior patterns; mostly facial expressions, body postures, and hand movements. The authors found that higher scores on the TAS-20 were significantly associated with less facial expression production, but significantly *more* postural, bodily and fidgeting nonverbal behaviors that indicate anxiety. The authors speculated that expressing emotions via facial expressions may *release* negative emotion, and that highly alexithymic individuals may experience more physiological anxiety as a result of suppressing emotional expression (thereby not releasing tension associated with negative emotion).

In contrast to studies finding a negative relationship between alexithymia and nonverbal facial displays, others have failed to find such an effect. Roedema and Simons

(1999) showed slides designed to elicit an array of positive and negative emotions to a sample of TD undergraduates. Compared to the low-alexithymia group, the high-alexithymia group displayed lower physiological arousal as measured by skin conductance response and heart rate deceleration in response to the stimuli (indicating less arousal), less self-reported emotional arousal, and produced less emotion-related words when describing how the slides made them feel. However, no relationship between alexithymia and facial expression production as measured by skeletal muscle response through electromyography (EMG) was observed. Luminet, et al. (2004) conducted a similar study with a sample of older TD adults, this time showing participants a short clip that was expected to elicit the emotion of sadness as it documented a woman's battle with cancer in a hospital. Luminet et al., (2004) also found that alexithymia was associated with lower self-reported emotional arousal and less use of emotion-related words and it was not significantly associated with facial expression production as measured by EMG. However, in contrast to Roedema and Simons' (1999) findings, alexithymia was associated with *more* physiological arousal as measured by heart rate in response to the emotional stimuli. Both Roedema and Simons (1999) and Luminet et al., (2004) reported very minimal production of facial expressions in their participants in response to the stimuli, and speculated that the stimuli may not have been sufficiently arousing to produce enough variability in facial expression production which resulted in nonsignificant relationships between alexithymia and facial expression production, or that the limited range of facial expressions may be a result of the limited muscle movements that EMG techniques are able to detect.

Overall, most studies reviewed in this section have found an inverse relationship such that higher alexithymia is associated with less facial expression production. However, there was little consensus as to why this relationship exists. While the studies presented in this dissertation do not aim to test differing theories, the focus is to extend this line of research to the ASD population where difficulties in social communication may be uniquely explained, in part, by the relationship between alexithymia and nonverbal expression.

1.6. Facial Expressions: How They Develop and the Functions They Serve

Emotional facial expressions facilitate many important social-emotional functions. Facial imitation (i.e., voluntary replication of another's facial expressions) and automatic mimicry (involuntary replication of another's facial expressions) are thought to be critical for empathetic and social cognitive processes (Neal & Chartrand, 2011; Rymarczyk, Żurawski, Jankowiak-Siuda, & Szatkowska, & 2016), and are crucial for developing rapport between two people during the relationship building process (Lakin, 2013). Facial expressions are also perhaps our most salient means for expressing emotions, and there is evidence to suggest that nonverbal indicators of emotional expression are more informative and trustworthy than verbal expressions of emotion. Indeed, Mehrabian and Ferris' (1967) classic study shows that in certain contexts up to 93% of particular types of information—*feelings* and *attitudes*—are conveyed nonverbally via facial expressions, body language, and vocal tone. Facial expressions show concern for others, they modify the meaning of spoken language, and provide a window into our internal emotional state to others. Thus, the appropriate use of facial expressions is a critical mechanism central to successful facilitation of social interaction and relationship building.

1.6.1. Development of Facial Expressions

Emotional facial expressions are present at birth, as evidenced by a crying infant, or expressions of contentment (Malatesta & Haviland, 1982). Thus, unlike many other nonverbal forms of communication (e.g., gesture), facial expressions are displayed before any social learning has taken place (Ekman, 2007; Izard, 1994). As early as 3 months old, infant facial expressions can become discernable according to emotions and mental states such as happiness, sadness, anger and interest (Malatesta & Haviland, 1982). As early as four weeks old, facial expressions become "social" in nature, as babies begin laughing jointly with others (Wolff, 1987), and the muscle movements that form facial expressions rapidly increase in complexity throughout the first year of life (Halberstadt, Parker & Castro, 2013). The meanings attributed by adults to the facial expressions of infants also rapidly increase in complexity as babies between the ages of 1 and 2 years old have at least four discernable smiles—simple (lip corner retraction only), Duchenne (simple plus cheek raising), play (simple plus jaw drop), and duplay (Duchenne plus jaw drop)—that vary systematically according to context (Fogel, Hui-Chin, Shapiro, Nelson-Goens, & Secrist, 2006; Messinger, Fogel, & Dickson, 2001).

While the extent to which facial expressions observed by adults reliably represent underlying emotions in young babies is questionable, Halberstadt et al. (2013) suggest that caregivers respond to their children's facial expressions as if they *do* represent emotions, by imitating expressions and empathizing according to the perceived emotional state. By implication, babies' emotional understanding is strongly influenced by socialization. More specifically, as babies increase in maturity and social experience, their ability to associate facial expressions with emotional states may become solidified through the *mirror* by which their own facial expressions are reflected in their caregivers (Halberstadt & Lozada, 2011). Gergely and Watson (1996, 1999) present a developmental model articulating the important role of parental affect-mirroring in the development of emotional self-awareness in early childhood. According to Gergely and Watson, babies first become sensitised—a non-associative learning process through which repeated exposure to a stimulus results in the progressive amplification of the reaction to the stimulus—to their categorical emotional states through their caregiver's reflections of the baby's emotion displays. These caregiver-baby interactions serve to regulate the babies' emotional states, but also serve as learning opportunities helping children develop the cognitive representations to associate internal and external representations of affect, and likely serve as foundations for which children can eventually use nonverbal cues such as facial expressions to intentionally convey communicative emotional messages (Gergely & Watson, 1996, 1999).

1.6.2. Spontaneous Facial Expressions

As will be explored again in Chapter 4, facial expression development can be usefully distinguished among *spontaneous* and *voluntary* expression. In this dissertation, spontaneous facial expressions are conceptualized as automatic reactions to internal thoughts or external stimuli in one's environment that trigger affective arousal and a corresponding emotional facial display (Kappas, Krumhuber & Küster, 2013). Frijda (1986) characterizes emotions as "relevance detectors" that indicate an external event that is highly important to the organism. The importance of this event in certain situations (e.g., the presence of danger) must be processed by the brain rapidly in a process Scherer (2005) refers to as "cognitive appraisal," in which the brain evaluates the eliciting event consciously or subconsciously. In such situations, facial expressions associated with the experienced emotion are involuntary, meaning they are automatically expressed as a consequence of affective arousal in the Autonomic Nervous System (ANS). Indeed, involuntary expressions are mediated by a subcortical area called the extrapyramidal system (Purves et al., 2014; Rinn, 1984; Tassinary & Cacioppo, 2000)—a system responsible for executing automatic muscle reflexes.

Charles Darwin (1872) was perhaps the first notable scholar to articulate the adaptive functions that spontaneous facial expressions serve in his book, *The Expression of the Emotions in Man and Animals*. In this book, Darwin argued that emotional facial expressions are present in non-human animals (particularly primates) with similar meaning to that of humans, and that facial expressions serve adaptive functions that increase an organism's chances of survival, suggesting such traits to be selected by the process of natural selection. For example, he argued that the widening of the eyes during expressions of fear or surprise allow more visual information to be rapidly processed aiding decision making and subsequent action to avoid potential threats to the organism. Others have since noted the survival value of facial expressions extends beyond the self (Ekman, 2006), signaling important communicative information to others (e.g., the expression of disgust to signal spoilt food). The seminal work of Ekman and others over the last 50 years revived and found empirical support for some of Darwin's ideas on the universality of facial expressions—namely, that "the universal in facial expressions of emotion is the connection between particular facial configurations and specific emotions" (Ekman, 2017, p. 50). For example, Ekman visited the Fore tribe in New Guinea, finding that these indigenous people expressed six basic emotions (fear, anger, disgust, sadness, joy and surprise) in such a way that Americans could correctly infer their intended emotional meaning, even though the Fore tribe had no previous contact with other societies than their own (Ekman, Sorenson, & Friesen, 1969). However, this claim that emotions are universally recognized from facial expressions has been challenged based on an argument that the methods used in relevant research studies lack ecological, convergent and internal validity, and that when these methods are altered, less supportive results have been found (see Russell, 1994, for a review).

While there may be a small number of emotion concepts (listed in the previous paragraph) that are relatively experienced and expressed in similar ways across cultures, there are many examples of emotion words and concepts that exist only in certain languages and cultures that have no direct translation in other languages (Russell, 1991; Wierzbicka, 1999). Indeed, The question of *"What is an emotion?"* has long been debated by philosophers and theorists since William James' (1884) seminal article with that very title. Since then, there has been remarkably little theoretical consensus in answer to that question—in part because emotions are abstract folk psychology concepts that are poorly and inconsistently defined both within laymen's language and within the scientific community (Scherer, 2005), and across cultures. It must be emphasized that the present dissertation considers emotion related lexicon, emotional experience, and emotional expression from the relatively narrow lens by which Western cultures define and conceptualize emotion.

1.6.3. Automatic Mimicry

Another context in which facial expressions are produced involuntarily is when we *automatically mimic* others' facial expressions—a process that may facilitate a specific set of social-emotional functions. A seminal study found that babies ranging from 0.7 to 71 hours old, reliably mimic mouth-opening and tongue-protrusion facial movements of an experimenter, suggesting that facial mimicry can be observed in newborns before any social learning or development of the visual and motor systems have taken place (Meltzoff & Moore, 1983). The authors speculate that their data indicates that infants come into the world with an innate capacity to "…relate proprioceptive/motor information about their own unseen body movements to their representation of the visually perceived model and create the match required" (Meltzoff

& Moore, 1983, p. 708). These innate mimicry processes present at birth are theorized to be a fundamental mechanism by which babies share mental and motor representations of others allowing them to learn from their social environment.

Automatic mimicry of facial expressions is commonly discussed in theoretical frameworks such as *Simulation theory* (Goldman & Sripada, 2005), *Embodied Cognition* (Winkielman, McIntosh, & Oberman, 2009) and *Emotional Contagion* (Hatfield, Bensman, Thornton & Rapson, 2014). A common theme throughout these theories is the assumption that individuals infer others' mental and emotional states by reproducing or experiencing the same states in themselves, and automatic facial mimicry appears to be a critical route by which this simulation process takes place. Oberman, Winkielman and Ramachandran (2007) demonstrated that selectively blocking the facial muscle movements of their participants (either by requiring them to chew gum or hold a pen in their mouths) impaired performance on an emotion recognition task compared to control groups whose expressions were not obstructed. However, Oberman et al. (2007) cautioned the interpretation of their own results, as they could have possibly been due to distraction—that holding a pen in one's mouth or chewing gum 'vigorously' as the participants were instructed could impair performance due to unintended strains on cognitive load. Neal and Chartrand (2011) developed an ingenious solution to Oberman et al.'s (2007) problem by conducting a similar study with participants who recently received Botox injections—a procedure that dampens facial muscular activity. Compared to participants who had never received Botox injections, participants who did receive Botox injections performed worse than a matched typical control group on an emotion recognition task. These studies suggest automatic mimicry facilitates emotion recognition, although others have cautioned that mimicry may simply be a by-product of affective arousal associated with the ANS (Ekman, 1992). Such an account would suggest that emotions are primarily simulated through specific patterning of autonomic processes such as heart rate and skin conductance and that motor expressions of emotions (e.g., facial expressions) are secondary.

One mechanism implicated in the processing and production of facial expressions is the Mirror Neuron System (MNS), which is thought to serve as an important bridge between visual processing areas and the motor cortex (Williams, Whiten, Suddendorf & Perrett, 2001). Mirror neurons are accordingly named due to their activation both when seeing an action and performing that action. Automatic mimicry and imitation have been hypothesized to be critical both for empathic processes and for understanding others' minds (Iacoboni, 2009). For example, Wicker, Keysers, Plailly, Royet, Gallese and Rizzolatti (2003) conducted a study using functional magnetic resonance imaging (fMRI) in which participants either experienced disgust or watched others experience disgust. In one condition, participants inhaled either pleasant, neutral or foul odors through a mask. In the other condition, participants watched videos of other participants complete the same tasks. The authors found that two neural regions—the left anterior insula and right anterior cingulate cortex—were activated when participants experienced disgust *and* when watching others experience disgust, beyond the activation of these same neural regions in response to the pleasant and neutral stimuli in either condition. Wicker et al. (2003) concluded that the same neural substrates are automatically activated both while observing others experience emotions (in this case, disgust) and when experiencing those emotions themselves.

1.6.4. Voluntary Expressions

Unlike spontaneous expressions and automatic mimicry which are *involuntary* processes that result from affective arousal or simulating others' expressions, *voluntary* expressions are consciously controlled and used for social communication purposes. The first step in the successful sending of emotional messages via voluntary facial expressions is an awareness that facial expressions have communicative value and that a message needs to be shared (Halberstadt, Denham & Dunsmore, 2001). It is quite difficult to determine when children first begin consciously controlling their facial expressions in the absence of authentic emotion because it is difficult to infer from observing real-world behavior whether facial expressions are spontaneous or voluntary. However, there is evidence hinting that this skill is developed as early as 10 months old (Fox & Davidson, 1988). Research has shown that genuine smiles resulting from authentic joy can be differentiated from voluntary smiles based on whether the orbicularis oculi is activated (Ekman, 1985; Ekman, Davidson, & Friesen, 1990). The orbicularis oculi is a facial muscle responsible for closing of the eyelids—it is observed as squinting during the experience of authentic joy, and is notoriously difficult to activate voluntarily (Ekman, 1985). Fox and Davidson (1988) observed 10-month old babies interacting with their mothers or women that were strangers to the babies and found that a) babies smiled in response to the initiations of both their mothers and the strangers, b) the babies' smiles were more likely to include activation of the orbicularis oculi when interacting with their mothers (indicating authentic joy), whereas smiles were more likely to *not* include activation of the orbicularis oculi when interacting with the strangers, and c) electroencephalogram (EEG) data revealed that smiles including the orbicularis oculi were primarily associated with left hemisphere activity, whereas smiles that did not include the orbicularis oculi were associated primarily with right hemisphere activity. These findings suggest that babies less than a year old have the capacity to voluntarily produce facial expressions to regulate social interactions, and that spontaneous and voluntary expressions are controlled by distinct brain regions. Indeed, subsequent research has revealed that unlike spontaneous expressions, which are involuntary and controlled by subcortical brain areas, voluntary expressions are operated within our conscious control, and are mediated by the pyramidal motor system—a cortical brain area that is responsible for communication in addition to a large number of intentional motor movements (Purves et al., 2014; Ross, Prodan, & Monnot, 2007).

"Display rules" within cultures dictate when it is appropriate to *regulate* emotional facial expressions in various social settings (Malatesta, & Haviland, 1982). While spontaneous expressions and automatic mimicry are *involuntary* responses to external stimuli or to others' facial expressions, voluntary expressions a) are consciously regulated, b) require accurate understanding of social contexts, c) require an understanding of the perspectives of other individuals involved in the social interaction, d) require the flexibility to modify one's nonverbal behavior according to the social context, cultural expectations, and situational demands of any given interaction, and e) require the ability to voluntarily and accurately express artificial emotional facial expressions to regulate social interactions and facilitate social goals (Kappas et al., 2013). The understanding of when and how to use voluntary facial expressions to regulate social interactions is learned and executed relatively effortlessly by TD individuals. However, due to impairments in social understanding, these skillsets may be particularly impacted in ASD.

1.7. Atypical facial expressions in ASD

While the atypical use of facial expressions is a noticeable clinical feature of many individuals with ASD (APA, 2013), this specific aspect of nonverbal communication has received little empirical attention. The existing literature on this topic is briefly summarized here, with a more exhaustive review provided in Chapter 2.

1.7.1. Empirical Evidence

Loveland, Tunali-Kotoski, Pearson, Brelsford, Ortegon and Chen (1994) compared a group of children and adults with ASD with a group of participants with Down Syndrome matched on chronological and mental age, on their ability to accurately produce voluntary expressions of emotion. Similar performance between groups was found for the *imitation* task that prompted participants to imitate models of facial expressions, but in a separate task where participants were instructed to pose various expressions without a model to imitate, the Down Syndrome group produced significantly more recognizable expressions than the ASD group. In addition, the expressions of the ASD group were subjectively rated as "more bizarre," appearing mechanical in nature with odd features (Loveland et al., 1994). A similar study—this time comparing ASD adults with TD comparisons matched on age and intelligence (IQ)—photographed "poser" participants as they posed emotional facial expressions to the best of their abilities in various conditions (Brewer et al., 2016). These photographs were then viewed by a separate set of "recognizer" participants with and without ASD who were asked to identify the intended emotion of each facial expression. Both TD and ASD "recognizer" participants were less able to correctly infer the intended emotion of the ASD "poser" expressions compared to the TD "poser" expressions. The findings from Loveland et al., (1994) and Brewer et al., (2016) point to the conclusion that children and adults with ASD display facial expressions that are more difficult for observers to understand compared to non-ASD comparison groups when participants are instructed to pose facial expressions based on verbal prompts, which may stem from impairments in associating internal emotional states (understanding one's own emotions) with external representations of emotion (e.g., facial expressions).

Other studies have examined the extent to which participants with and without ASD matched on age and IQ automatically mimic facial expressions. McIntosh, Reichmann-Decker, Winkielman and Wilbarger (2006) administered a simple viewing task of emotional expressions to ASD and TD participants, and measured automatic mimicry using electromyography (EMG) which captures muscle movements within the face. In one condition, they indexed the amount of muscle activity, as well as the accuracy by which expressions were mimicked. While there were no significant group differences in overall amount of muscle activity, the ASD group expressed emotions with significantly less accuracy as demonstrated by the fact that the facial activity of participants with ASD was more likely to be incongruent with the expression they were mimicking compared to the TD group. In a separate condition when participants were explicitly instructed to imitate the emotional expressions in the stimuli, no group difference in the accuracy with which facial expressions were imitated was observed. This led the authors to infer that automatic mimicry, but not voluntary facial imitation, is impaired in ASD. However, Magnée, de Gelder, van Engeland, and Kemner (2007) conducted a very similar study that presented facial expression stimuli to adults with ASD and found significantly *heightened* automatic mimicry accuracy as measured by congruent EMG facial muscle responses to that of the stimulus being mimicked. Magnée et al. (2007) suggested that the difference between their results and McIntosh et al.'s (2006) results may have been due to differing task demands. In Magnée et al.'s (2007) study, participants were asked to judge the sex of the face stimuli, whereas McIntosh et al.'s participants passively viewed the face stimuli. Therefore, participants in Magnée et al.'s study may have displayed more visual attention to the face of the stimuli which led to more accurate automatic mimicry (although this explanation is speculative, and there is no data in either study to confirm this).

Rather than examining the intensity of automatic mimicry, some studies have examined reaction times (i.e., amount of time between exposure to an emotion-eliciting stimulus and spontaneous facial expressions). While some researchers have found delayed reaction times in ASD compared to TD comparisons (e.g., Oberman, Winkielman & Ramachandran, 2009), others have failed to find ASD and TD group differences in reaction time (Schulte-Rüther et al., 2017; Sterling et al., 2013). If individuals with ASD are less likely to automatically mimic others facial expressions, or do so with less speed and accuracy, then deficits in automatic mimicry may be an important mechanism contributing to the social-emotional reciprocity impairments that are characteristic of ASD (APA, 2013). However, given the conflicting pattern of results, the meta-analysis conducted in Chapter 2 will be useful in determining whether automatic mimicry is impaired in ASD across studies.

While the aforementioned studies in this section used tightly controlled experimental designs, other studies examined facial expression production in children during unstructured observational studies of free play with other children, parents or experimenters. Yirmiya, Kasari, Sigman and Mundy (1989) analyzed videotapes of children interacting with experimenters who were initiating games, showing toys, and engaging in turn-taking activities. Compared to a non-ASD intellectually delayed group matched on mental age, the ASD group's facial expressions were rated as more flat or neutral, and demonstrated "ambiguous" expressions that were not interpretable or expressed by the other children. Another study that compared parent-child play interactions in ASD and TD comparison groups matched on chronological and mental age, found that the ASD group was not necessarily less expressive overall, but made significantly *less* "social" expressions (directed towards or shared with their parents), and *more* expressions while playing in isolation that were not directed at others (Snow, Hertzig & Shapiro, 1987). These studies suggest that in naturalistic settings, individuals with ASD are generally less facially expressive, particularly when facial expressions are directed at others for the purposes of regulating social interactions. A particular interest of the meta-analysis in Chapter 2 will be to examine whether ASD-comparison group differences in facial expressions vary according to differing methodological factors (e.g., in contexts where facial expressions are expressed naturally as part of naturalistic interactions compared to laboratory contexts in which participants are explicitly instructed to pose or imitate facial expressions).

1.7.2. Theories Addressing Atypical Facial Expressions in ASD

In the existing literature, theoretical explanations for atypical facial expressions in ASD are generally vague if not altogether absent. However, the nature of atypical facial expression development can be inferred from dominant developmental perspectives of ASD. These perspectives describe the social and communication deficits characteristic of ASD as stemming from deficits in the Mirror Neuron System, deficits in "mentalizing," or deficits in social motivation.

Mirror Neuron System (MNS) Impairment

Given that deficits in social and emotional reciprocity are present in infancy and throughout the lifespan in ASD (APA, 2013), mirror neurons are a plausible source of such impairment. Indeed, the most highly accepted neurological explanations of ASD suggest that, rather than any one executive system being especially disrupted in ASD, functional connectivity problems (i.e., integration and coordination) among intra-hemispheric brain regions best characterize the neurobiology of ASD (Minshew & Williams, 2007), with mirror neurons being one such mechanism for coordination between visual and motor systems (Williams et al., 2001). Evidence for the role of mirror neurons in atypical facial expressions in ASD comes from an fMRI study that demonstrated significantly reduced activation in the inferior frontal gyrus (IFG)—one of the core brain regions implicated in the MNS (Rizzolatti & Craighero 2004)—in ASD compared to TD children when viewing and imitating emotional facial expressions (Dapretto et al., 2006). This study also revealed a negative correlation between IFG activation and ASD symptom severity within the ASD participants. The MNS appears to be particularly important for automatic mimicry which may aid empathetic and social cognitive processes. That said, MNS impairment present in early childhood may significantly impair the ability of individuals with ASD to learn from and understand others' mental states and can lead to a cascade of social and emotional differences (Williams et al., 2001) that could plausibly impact the quality and accuracy of facial expressions in other contexts besides mimicry. For example, in some cases automatic mimicry may *lead* to affective arousal via emotional contagion (Hatfield et al., 2014) which may serve as an important feedback loop solidifying the relationship between internal (affective arousal) and external (e.g., facial expressions) representations of emotion (Winkielman et al., 2009).

The MNS theory of ASD has received mixed empirical support. A systematic review of brain-imaging studies found minimal evidence of MNS differences in ASD (Hamilton, 2013). Hamilton concluded that studies that examined MNS activity when imitating non-emotional hand action stimuli generally have not reported ASD-comparison group differences, whereas a subset of studies using emotional stimuli have found group differences. Thus, while the MNS theory may not be sufficient in explaining all major components of social and communication impairments in ASD, it may be particularly relevant for contributing to deficits in social-emotional reciprocity or other emotion-specific abnormalities in ASD.

Mentalizing Frameworks

In naturalistic contexts, the appropriate use of facial expressions requires accurate understanding of social contexts and the mental states of others, as well as the flexibility to modify one's own nonverbal behavior according to the social context and situational demands of any given interaction (Kappas et al., 2013). The mentalizing framework suggests that people with ASD have deficient cognitive mechanisms necessary for understanding others' mental states such as beliefs, desires, emotions and intentions (Baron-Cohen, 1995, 2005). Over the course of development, these difficulties may negatively impact the ability to interpret others' facial expressions, making it difficult to associate emotional meaning with emotional facial expressions of the self and others (Bird & Viding, 2014). Relatedly, mentalizing difficulties may adversely impact one's ability to understand social situations and others' perspectives necessary for appropriately incorporating and integrating nonverbal cues of emotion such as facial expressions into verbal exchanges (APA, 2013). Thus, mentalizing deficits may impair the accuracy and quality with which facial expressions are displayed, especially when utilizing facial expressions to regulate social interactions.

The mentalizing framework originated from the closely related "Theory of Mind" (ToM) explanation of autism, which posits that children with ASD lack the ability to attribute independent mental states to others in order to explain and predict behavior (Baron-Cohen, 2001; Baron-Cohen, Leslie, & Frith, 1985). The ToM and Mentalizing frameworks have been enormously influential in generating empirical research and shaping current understanding of the social and communication deficits of ASD. However, based in part by limited and conflicting evidence that people with ASD are impaired at passing “false belief tasks”—tasks that require participants to understand the perspectives and subsequent behaviors of characters in a vignette who have access to differing information than the participants—these theories have declined in popularity (Boucher, 2012; Frith & Happé, 1994). Whereas mentalizing deficiencies were first conceptualized as a *cause* of autistic impairment, mentalizing deficiencies are now more commonly thought of as a consequence of different causal mechanisms, such as impairments in social motivation brain networks.

Social Motivation

Social motivation theories of ASD (Chevallier, Kohls, Troiani, Brodkin, & Schultz, 2012) suggest that for people with ASD, social information (e.g. faces and voices) is less intrinsically rewarding (Grelotti, Gauthier, & Schultz, 2002; Schultz et al., 2000; Schultz, 2005; Zeeland, Ashley, Dapretto, Ghahremani, Poldrack, & Bookheimer, 2010), possibly due to differences in the amygdala (Schultz, 2005; Zald, 2003) and the dopamine system (e.g., Dichter & Adolphs, 2012). For example, one of the earliest reliable indicators of an impending ASD diagnosis in babies with ASD is a reduced tendency to focus their attention towards faces (Szatmari et al., 2016; Zwaigenbaum, Bryson, Rogers, Roberts, Brian & Szatmari, 2005). As this theory describes, reduced social attention will lead to repeated missed social and emotional learning opportunities throughout development that will compound to impair social abilities, including the abilities to infer others’ mental states (Chevallier et al., 2012). While this theory does not directly address the development of facial expression production, it is possible that early impairments in social attention will lead to reduced opportunities for facial mimicry and imitation behaviors between babies and caregivers. In turn, missing out on social-emotional learning opportunities during critical developmental periods may lead to downstream effects on atypical facial expression production in addition to other social-emotional impairments characteristic of ASD. The social motivation theory remains one of the most widely accepted theories as a causal explanation for social and communication impairment in ASD.

A Pervasive Gap in ASD and Facial Expression Theories

No one theory can explain the full extent and different aspects of facial expression differences observed in ASD. Multiple mechanisms are likely at play (e.g., impaired mentalizing, reduced social motivation, dysfunctional MNS), and these mechanisms may be more or less relevant at different times or in different individuals. Critically, none of these theories attempt to clarify *individual differences* in facial expression production within the ASD population, and none of these theories consider how difficulties with *internal awareness* of emotions (e.g., alexithymia) may impact the nonverbal expression of emotions in ASD. This dissertation aims to identify how individual differences in alexithymia may account for variance in facial expression abilities, and to investigate whether different mechanisms may be associated with different types of facial expression production. The following research studies will help create a more parsimonious understanding of the nature and extent of atypical facial expressions in ASD (Chapter 2) and a better understanding of the social-emotional difficulties of ASD that may be accounted for by alexithymia (Chapters 3 and 4)—which in turn may have important clinical implications for identifying and potentially treating alexithymia as a modifiable pathway in ASD (Chapter 5).

1.8. The Present Studies

As a first step for understanding atypical facial expressions in ASD for my doctoral research, I will systematically review all studies that have compared facial expression production abilities between participants with ASD and non-ASD comparison groups using meta-analysis to summarize what is known about facial expressions in ASD. As will be described in detail in Chapter 2, there is substantial variability in the research questions, methods, and findings in the extant literature on facial expressions in ASD. Thus, the meta-analysis will use subgrouping methods to identify which aspects of facial expressions are impaired or intact in ASD compared to non-ASD comparison groups and use moderator analyses to identify methodological and demographic variables that may account for the equivocal pattern of research findings that exist in the extant literature.

Building from the findings of Chapter 2, Chapter 3 will seek to extend the 'alexithymia hypothesis' to an area of study that has yet to be investigated—the production of facial expressions. As described in Section 1.4, studies investigating the 'alexithymia hypothesis' to date have explored the role of alexithymia in atypical interoceptive sensitivity (Shah et al., 2016) and neural activation in interoceptive brain regions involved in empathic processes (Bird et al., 2010), as well as atypical social cognition related to face scanning (Bird et al., 2011) and emotion recognition (Cook et al., 2013). An important avenue to extend the alexithymia hypothesis that has not yet been explored, is to examine the role that alexithymia may play in atypical facial expression in ASD. Based on the literature reviewed in Section 1.7 and from descriptions in the DSM-5 (APA, 2013), an anticipated finding from Chapter 2 is that participants with ASD will be generally less expressive, such that they produce facial expressions less frequently and for less duration in response to emotional stimuli or in social interactions. Given the research reviewed in Section 1.5 on the relationship between alexithymia and reduced facial expression production in non-ASD populations, and given the findings that individuals with ASD may have significantly heightened alexithymia (Hill et al., 2004), Chapter 3 explored the potential link between alexithymia and reduced facial expression in ASD.

As the link between alexithymia and facial expression production in ASD was confirmed in Chapter 3, Chapter 4 sought to develop a more nuanced understanding of how alexithymia and ASD traits may be related to different types of facial expression production in the general population. As was reviewed in Section 1.6, spontaneous and voluntary facial expressions serve different social functions and are modulated by different brain regions. Thus, alexithymia and ASD traits may differently impact spontaneous and voluntary expression production. Alexithymia seems to be associated with a general disposition towards not expressing emotion verbally or nonverbally (Wagner & Lee, 2008). As such, it was predicted that individuals with higher levels of alexithymia may be less likely to *spontaneously* produce emotional facial expressions when they are not experimentally prompted to do so. However, the relationship between alexithymia, ASD traits and *voluntary* expression is less clear. Given the mentalizing deficits characteristic of ASD, heightened ASD traits may negatively impact one's ability to associate emotional meaning with emotional facial expressions of the self and others (Bird & Viding, 2014), impairing an individual's ability to voluntarily provide others with the nonverbal information needed to accurately convey posed expressions. For this reason, voluntary expressions were predicted to be more strongly related to ASD traits than alexithymia.

Chapter 2.

A Meta-Analysis of Facial Expressions in Individuals with ASD

2.1. Introduction

In the general population, atypical production of facial expressions is correlated with lower social competence (Nowicki & Duke, 1994) and perceptions of unnatural facial expressions can reduce the fluidity of social exchanges (Halberstadt et al., 2001). Facial expressions are highly nuanced and represent multiple social skillsets and emotional processes—in different contexts, emotional facial expressions can be either an involuntary product of affective arousal (e.g., smiling at something humorous), or a voluntary display used for social communication purposes (e.g., smiling at an acquaintance). We also automatically and subconsciously mimic others' facial expressions which is thought to be one route by which we infer others' emotional states (Neal & Chartrand, 2011; Niedenthal, Brauer, Halberstadt, & Innes-Ker, 2001), and we intentionally imitate others' expressions which is crucial for building social-emotional reciprocity and rapport, or displaying concern and empathy (Lakin, 2013). As such, a more sophisticated understanding of the precise nature and extent of atypical facial expressions in individuals with ASD may shed light on how atypical facial expressions relate to the broader social impairment of ASD.

The intent of this meta-analysis is to a) summarize what is known about facial expression production in ASD, b) evaluate which aspects of facial expression production in individuals with ASD are impaired or intact relative to typically developing and clinical comparison groups, and c) identify the ASD sample characteristics, matching procedures, and other methodological variables that may moderate the strength of ASD-comparison group differences in facial expressions. For example, one of the key sources of contention in the field is whether both involuntary (i.e., spontaneous expression and automatic mimicry) and voluntary facial expressions are impaired in ASD or if voluntary expression is relatively intact in this population. As McIntosh et al. (2006) and others have demonstrated, individuals with ASD may automatically mimic facial expressions with less accuracy (i.e., lower congruency with the expression being mimicked) in response to external emotional stimuli but appear to be less impaired in accurately voluntarily portraying expressions when instructed to do so in the confines of a laboratory setting. However, in contrast to McIntosh et al.'s (2006) findings, other studies have found *heightened* automatic mimicry accuracy in ASD when viewing facial expression stimuli (Magnée et al., 2007) and other studies have found impairments in voluntary expression accuracy (Brewer et al., 2016). These and related issues will be systematically investigated using meta-analysis to identify the true nature and potential sources of facial expression impairment in individuals with ASD. By identifying the methodological features that moderate the strength of ASD-comparison group differences in facial expression abilities, I can speculate on the underlying mechanisms contributing to atypical facial expressions in ASD and provide insights into which social-emotional competencies are impaired or intact in this population.

2.1.1. Summary of Relevant Empirical Research

Most existing research shows that individuals with ASD display facial expressions differently than TD or non-ASD clinical comparison groups. Children with ASD tend to display facial expressions less frequently and for shorter duration of time during naturalistic social interactions (Czapinski & Bryson, 2003; Loveland et al., 1994). Experimental studies have demonstrated that participants with ASD are less likely to automatically mimic others' expressions and do so with less accuracy (Yoshimura, Sato, Uono & Toichi, 2015; McIntosh, et al., 2006). A number of studies have shown that when present, the facial expressions of persons with ASD may be atypical in appearance, rated as more awkward, odd or mechanical (Faso, Sasson & Pinkham, 2015; Grossman, Edelson, & Tager-Flusberg, 2013; Loveland et al., 1994; Macdonald et al., 1989). In some cases, these atypical features of facial expressions make it difficult for others to interpret the intended emotional meaning when participants are prompted to pose various emotional expressions (Brewer et al., 2016; Smith, 2007; Stel, van den Heuvel, & Smeets, 2008). Other studies show that individuals with ASD produce facial expressions that are less "socially congruous" (i.e., appropriate to the social context). For example, several studies observed that compared to developmentally delayed comparison participants without ASD, children with ASD were less likely to share affect with their mothers or other adults during naturalistic interactions (Dawson, Hill, Spencer, Galpert, & Watson, 1990; McGee, Feldman, & Chernin, 1991; Snow et al., 1987; Tantam, Holmes & Cordess, 1993), but were more likely to display positive affect during self-absorbed activity (Snow et al., 1987).

Despite these findings, the existing research on facial expression production in ASD has yielded an inconsistent pattern of results. In contrast to predictions, Faso et al., (2015) found that when prompted to pose various emotional facial expressions, the expressions of participants with ASD were significantly *more* recognizable compared to expressions of TD participants, although this may have been due to the finding that ASD participants expressed emotions in a more exaggerated fashion as reported by the authors. Capps, Kasari, Yirmiya and Sigman (1993) also found an unexpected pattern of results from observational and parent-report data. Compared to mothers of TD children, mothers of children with ASD reported more observations of negative affect, but fewer observations of positive affect. Additionally, in response to viewing emotionally arousing videos designed to elicit empathy, children with ASD displayed significantly more spontaneous negative and positive facial expressions (Capps et al., 1993). Several other studies have failed to find ASD-comparison group differences in the accuracy with which participants intentionally imitate facial expression stimuli (McIntosh et al., 2006), the amount of time between exposure to stimulus and facial expression onset (i.e., reaction time; Press, Richardson, & Bird, 2010; Sterling et al., 2013), and the intensity with which emotions are expressed (Mathersul, McDonald, & Rushby, 2013a).

2.1.2. Conceptualization and Operationalization of Facial Expressions

A conclusion that can be drawn from a review of the existing research on facial expressions in ASD is that there is not one underlying “facial expression ability.” Rather, researchers in this area have conceptualized and operationalized facial expression variables in many ways to investigate a diverse array of social-emotional competencies. Some studies have conceptualized facial expression abilities based on dimensions of *visual appearance* of facial expressions, which represents the degree to which facial expressions appear consistent with typical developmental norms and accurately represent the emotions they are intended to convey. Visual appearance has been operationalized as subjective ratings of participant expressions on dimensions such as “quality” or “awkwardness” using Likert Scale judgments, while other studies require participants to pose various expressions, and operationalize facial expression “accuracy” based on others’ ability to correctly identify the emotional meaning of their expressions. Other researchers have conceptualized facial expression abilities based on dimensions of overall *expressiveness*, which represents how much, how often and how saliently emotions are expressed. Such studies have operationalized expressiveness as the number of (i.e., frequency) or amount of time (i.e., duration) that facial expressions are displayed during a certain amount of time, while others have examined dimensions such as “intensity” of expression or amount of time between exposure to an arousing stimulus and facial expression onset (i.e., reaction time). Finally, other researchers conceptualized facial expression abilities based on the extent to which they are *reciprocated* in social contexts, examining whether facial expressions are used appropriately to regulate social interactions or to identify deficits in social-emotional reciprocity. Researchers have operationalized reciprocity either by quantifying the degree to which facial expressions are shared in naturalistic settings, or by the extent or accuracy by which observers automatically mimic facial expression stimuli. As summarized in Table 2.1, facial expressions were measured in diverse ways across studies; therefore, as shown in Table 2.2, conceptually discrete facial expression variables were created for the purpose of comparison and review.

Table 2.1. Methods for Measuring Facial Expressions

Electromyography (EMG)	Involves placing electrodes on the face to measure electrical activity produced by skeletal muscles. Typically measures activation of zygomaticus (joy) and corrugator (fear) activity in response to visual, auditory, or olfactory stimuli.
Subjective Rater Judgments	Typically involves subjective ratings of certain dimensions of facial expressions such as "Awkwardness" or "Intensity" using Likert scales.
Objective Rater Judgments	Typically involves participants posing various facial expressions, and a separate group of raters attempting to infer the intended emotional meaning of each expression.
Facial Expression Analysis Software	Software that estimates which emotion(s) are present based on video images of facial expressions. Software is typically programmed to make estimates using the Facial Action Coding System.

2.1.3. The Present Study

As many of the studies reviewed suffer from low statistical power (due to low sample size), a meta-analysis of the literature may provide a more accurate estimate of the true ASD-comparison group differences in facial expressions by creating average weighted effect sizes across studies and by identifying potential moderator variables that may clarify and explain variation in effects. One previous article reviewed some of the ASD facial expression production literature as part of a larger review on emotional competencies in individuals with ASD (Begeer, Koot, Rieffe, Terwogt, & Stegge, 2008). However, this article only commented on a portion of the existing literature and does not include any of the existing research on facial expressions published since 2008. To my knowledge, no review or meta-analysis that systematically reviewed the relevant literature on facial expression production in ASD has been published to date.

2.2. Method

2.2.1. Procedure

A systematic literature review was conducted in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines

(Moher, Liberati, Tetzlaff, & Altman, 2009). PsycINFO, PsycARTICLES, Web of Science, & PubMed were searched using search terms “(Autis* OR asperge* OR pervasive developmental disorder* OR HFA OR PDD OR ASD) AND (facial OR express* OR imitat* OR mimic*).” Additional hand searches reviewed articles and dissertations published since 1990 in *Autism: The International Journal of Research and Practice, Journal of Autism and Developmental Disorders*, *Autism Research*, *Molecular Autism*, *Research in Autism Spectrum Disorders,* and *Focus on Autism and Developmental Disorders.* Additional string searches were made from the reference lists of recently published articles on facial expressions in ASD. In total, 1309 prospective manuscripts were retrieved.

2.2.2. Inclusionary Criteria

To be deemed eligible for inclusion, several criteria must have been met:

1. The study examined emotional facial expressions in participants with and without ASD and reported group differences in *observable* facial behaviors.
2. Participants in the ASD group must have been diagnosed with Autism Spectrum Disorder (ASD), Asperger’s Syndrome, Pervasive Developmental Disorder, or Autistic Disorder based on DSM-III, DSMI-IV, DSM-V, ICD-10 (World Health Organization, 1987), Rutter, (1971, 1978), or Wing and Gould (1979) criteria. Diagnoses were reportedly made by a psychiatrist or mental health professional licensed to diagnose ASD in individuals.
3. A TD or non-ASD clinical comparison group must have been used as a comparison group in the study.
4. Original data was published in peer-reviewed journal articles or in unpublished dissertations.
5. The study was written in English.
6. The date of publication was 1967 to 2017.
7. The study must have sufficient data available on facial expression measures to calculate ASD-comparison group effect sizes using Hedge’s g.
8. Data was collected at a time point that was prior to any intervention or experimental manipulation.

2.2.3. Exclusionary Criteria

1. Studies that examined non-emotional facial expressions were excluded (e.g., imitation paradigms that require participants to protrude their tongue).
2. Studies that did not report observable facial behaviors (e.g., neurological studies that exclusively reported group differences in brain activity while displaying facial expressions) were excluded.

2.2.4. Study Coding Procedures

Codes were created for study descriptors and variables necessary to calculate effect sizes. Study descriptors are needed to establish external validity of the report and for their potential to account for variability in the average weighted effect sizes. Codes included: date of study, study location, diagnostic criteria used for ASD participants, matching procedures, outcome measures, description of experimental procedures, and sample characteristics (age, level of intellectual functioning). To establish validity of the coding procedure, a second researcher coded 15% of all studies yielding strong interrater reliability (Cohen’s kappa = .955). Given the diverse ways in which facial expressions were quantified in their respective studies, effect sizes were categorized into seven facial expression outcome variables (see Table 2.2).

Table 2.2. Descriptions of Each Facial Expression Outcome Variable

Outcome Variables	Description
Intensity	On a range from mild to extreme expression. Measured by EMG peak amplitude, or subjective experimenter ratings.
Frequency/Duration	The presence or absence of emotional facial expressions in various contexts. May include number of times or amount of time facial expressions are observed during naturalistic play settings or may indicate whether or not emotional expressions are elicited in response to various emotional stimuli. In some studies, frequency/duration was measured in paradigms where participants automatically mimicked facial expression stimuli. In such instances, this variable captures any emotional facial response to the observed stimulus, whereas the "Automatic Mimicry Accuracy" variable captures only emotional responses that are congruent with the stimulus.
Expression Quality	This variable mainly includes Likert scale ratings of "awkwardness," "oddness," or "quality" of expression. Also includes experimenter coding of observed peculiarities in expression, blended expressions or atypical facial muscle movements.
Voluntary Expression Accuracy	Relevant to studies in which participants were instructed to pose specific emotional facial expressions, either from verbal prompts or by intentionally imitatingfacial stimuli. This variable was operationalized as a) the degree to which others can correctly interpret the intended emotion, or b) Likert scale judgments of expression accuracy.
Automatic Mimicry Accuracy	Accurate involuntary replication of another's facial expressions during live interactions or in response to facial expression stimuli. Involves the detection of muscle movements that are congruent to that of the face being mimicked. All studies coded into this variable represent automatic mimicry, such that participants were not prompted to mimic.
Social Congruency	Emotion conveyed by a facial expression is contextually appropriate as it aligns with social expectations in naturalistic contexts. May involve social-emotional reciprocity (sharing affect with another person) or may reflect congruency between the facial expressions and situational context.
Reaction Time	The lag between exposure to emotion-eliciting stimuli (e.g., disgusting odors or startling noises/sensations), and the onset of participant facial expression.

2.2.5. Hypothesized Moderating Variables

Several variables are hypothesized to moderate the strength of ASD-comparison group effect sizes. These variables include experimental strategies to elicit facial expressions, strategies for matching ASD and comparison groups, and participant demographics—age, and intellectual functioning.

Covert elicitation/explicit elicitation

In some studies, researchers used *covert* facial expression elicitation strategies, in which participants were not explicitly instructed to produce facial expressions. Studies were coded as 'covertly elicited' when facial expressions were elicited spontaneously via affective arousal (e.g., exposure to disgusting odors or startling noises), expressed automatically via automatic mimicry (i.e., exposure to facial expression stimuli), or observed in real-world social interactions where participants' production of facial expressions emerged naturally as part of the dynamic social interplay. Studies were coded as 'explicitly elicited' when researchers gave participants *explicit* instructions to pose facial expressions voluntarily or to intentionally imitate facial expression stimuli.

McIntosh et al., (2006) was interested in this distinction between covertly and explicitly elicited facial expression production. In one condition, they measured the accuracy by which participants automatically mimicked the static facial expression images and found that the ASD group mimicked the images with less accuracy compared to a TD control group. In another condition, participants were instructed to voluntarily imitate the images, and no significant group differences in expression accuracy were observed. This led the authors to infer that automatic mimicry, but not voluntary imitation is impaired in ASD. This conclusion parallels the notion that while persons with ASD may perform differently from TD persons in unstructured everyday settings, they may be less impaired when instructed to do so in a controlled laboratory setting (Klin, Jones, Schultz, Volkmar, & Cohen, 2002). However, in McIntosh et al.'s (2006) study, both groups performed at or near ceiling level (100% accuracy for the TD group, and 96% accuracy in the ASD group), potentially masking group differences. Thus, a moderation analysis was conducted to determine if the dissociation reported by McIntosh et al.

(2006) persists across the larger literature base. However, as meta-analyses are meant to be as “inclusive” as possible to include a diverse array of studies, a broader approach to answering this question was taken. While McIntosh et al. (2006) only examined distinctions between automatic mimicry and voluntary facial imitation, this meta-analysis will examine the distinction between all studies in which facial expressions were *covertly* elicited (i.e., spontaneous facial expression production via affective arousal, automatic mimicry, or within naturalistic social interactions), versus studies in which facial expressions were *explicitly* elicited (i.e., voluntarily posing expressions on command, or voluntarily imitating facial expression stimuli in response to explicit instructions to do so).

Age and Intellectual Functioning

Differing participant characteristics of the samples from each study may influence the strength of ASD-comparison group differences in facial expressions. For example, facial expression production abilities may vary as a function of chronological age and intellectual functioning. Due to improvements in social understanding resulting from accumulating life experiences, it is possible that with increasing age and higher intellectual functioning, individuals with ASD develop compensatory strategies for producing facial expressions that are more typical in appearance and match the situational demands of various social contexts. I predicted that age and intellectual functioning will uniquely moderate ASD-comparison group effect sizes such that higher age and intellectual functioning among individuals in the ASD group will be associated with smaller group performance differences on facial expression measures.

Matching procedures

Because the studies reviewed in this meta-analysis employ observational designs that compared samples of ASD participants with non-ASD comparison groups, it is important to consider how participant groups were matched. Many researchers strive to match their groups on intellectual functioning and age. However, this is not always feasible for studies utilizing participants with ASD with comorbid intellectual impairment. Thus, researchers are sometimes faced with the decision to match on either age or intellectual functioning. In such cases, group differences in age or intellectual functioning (depending on the matching procedures) may confound observed ASD-comparison group differences on facial expression variables. I predicted that studies with the most stringent matching procedures with respect to age and intellectual functioning will yield the smallest ASD-comparison group differences because observed effect sizes in such studies will be less subject to the potential confounding influences of age and/or intellectual functioning.

2.2.6. Data Analysis Plan

Effect size Calculation

Hedges' *g* was used to report ASD-comparison group differences on facial expression variables. Hedges' *g* is more commonly reported in meta-analysis as an unbiased effect size as it corrects for inherent bias due to variation in sample size among studies (Hedges, 1981). The strength of Hedges' *g* can be interpreted similarly to that of Cohen's *d*—effect sizes approximate to 0.2, 0.5, and 0.8, can be loosely interpreted as small, moderate, and large effects, respectively (Cohen, 1988).

Statistical analysis of effect sizes

Summary effects for each outcome variable were computed using a random effects model. Random effects models assume that the studies were drawn from diverse populations and that this diversity (including participant characteristics and methods used to examine ASD-comparison group differences) accounts for variation in effect sizes found. Unlike fixed effects models which assume that the 'true' effect size is the same across all studies (and variation in effect sizes are due to random measurement error), random effects models do not assume a common effect size across all studies and attribute variation in effect sizes to methodological differences between studies. Thus, for fixed effects models, summary effect sizes represent the 'true effect size,' whereas for random effects models, summary effect sizes represent the weighted means of the distribution of effects (Borenstein et al., 2009). One of the key differences in the calculation of summary effects in fixed versus random effects models is that in fixed effects models, small studies are assigned relatively less weight than in random effects models whereas large studies are assigned relatively more weight than in random effects models. This is because in fixed effects models, differences between the effect sizes from small studies and the summary effects are considered to be due to imprecise measurement, whereas effect sizes from small studies in random effects models are deemed to be ‘true,’ representing information about the summary effects that no other study has estimated. Another key difference is that in fixed effect models, there is only one explanation for effect size variation (measurement error), whereas for random effects models effect size variation is attributed to measurement error *and* between studies variance. Because of this additional source of ‘uncertainty’ in random effects models, it follows that the variance, standard error, and confidence intervals for summary effects will be larger and wider. For each analysis, I calculated the mean and confidence intervals for weighted effect sizes calculated from Hedge’s g:

$$g = \left(1 - \frac{3}{4N - 9}\right) d$$

2.3. Results

2.3.1. Summary of all Studies

In total, 39 studies from 37 separate published articles and unpublished dissertations yielding 67 effect sizes were deemed to have met the inclusion criteria and therefore included in the meta-analysis. The total sample size of this meta-analysis is N = 1358 (ASD n = 684, comparison group n = 674). Table 2.3 provides a description of the authors, year of publication, sample characteristics, task procedures, outcome variables and effect sizes for each of the 39 separate studies.

Table 2.3. Summary of sample characteristics, task procedures and effect size information for all studies.

Study (date)	**ASD group characteristics**						**Comparison group**		**Group Matching**	**Task in Which Facial Expressions were Observed**	**Outcome Variables**	**N of ES**	**ES**
	N(f)	Age (years)	Intellectual Functioning	Measure; intellectual functioning construct = Mean (SD)	Diagnostic criteria	Confirmation Method	N(f)	Diagnosis					
Brewer et al. (2016)	15(3)	44.86	Not reported	WASI or WAIS; Not reported	Not reported	ADOS	12(0)	TD	Intellectual functioning only	Verbally prompted to pose facial expressions	Voluntary Expression Accuracy	1	-.395
Capps et al. (1993) Exp. 1	15(1)	12.17	Normal range	WISC; MA = 12.38 (2.34)	DSM-III	ABC	17(2)	TD	Age and intellectual functioning	Spontaneous expression while watching emotionally arousing videos	Frequency/ Duration	1	.764
Czapinski & Bryson (2003)	15(3)	5.84	Not reported	Not Applicable	Not reported	Not Specified	15(3)	TD	Intellectual functioning only	Natural expression during semi-structured play	Expression Quality	2	-1.346
											Frequency/ Duration		-1.318
Dawson et al. (1990)	16(3)	4.13	Intellectually disabled	RDLS; VMA = 1.55 (0.70)	Not reported	CARS	16(3)	TD	Intellectual functioning only	Natural expression during free play	Frequency/ Duration	2	-.593
											Social Congruence		-.851
Faso et al. (2015)	6(3)	24.00	Normal range	WASI; FIQ = 106.2 (14.2)	Not reported	ADOS	6(3)	TD	Intellectual functioning only	Verbally prompted to pose facial expressions	Expression Quality	3	-1.080
											Intensity		.457
											Voluntary Expression Accuracy		.242
Gordon et al. (2014)	17(NR)	10.76	Normal range	K-BIT; FIQ = 108.94 (5.24)	Not reported	ADOS, ADI-R	17(NR)	TD	Age and intellectual functioning	Verbally prompted to pose facial expressions	Expression Quality	1	-.797
Grossman et al. (2013)	18(1)	13.83	Normal range	K-BIT-2; FSIQ = 109.17 (13.61)	Not reported	Not Specified	11(0)	TD	Age and intellectual functioning	Instructed to repeat a story in an engaging way	Expression Quality	3	-.815
											Frequency/ Duration		.374
											Intensity		.217
Helt & Fein (2016)	43(5)	11.60	Normal range	SBIS; MA = 10.6 (2.7)	DSM-IV	ADOS	43(7)	TD	Intellectual functioning only	Spontaneous expression while viewing entertaining cartoons	Frequency/ Duration	1	-.488
Kasari et al. (1990)	18(4)	4.44	Intellectually disabled	CIIS or SBIS; MA = 2.15 (0.76)	DSM-III	Not specified	18(4)	TD	Intellectual functioning only	Natural expression during structured researcher-participant interaction	Social Congruence	1	-.341
Langdell (1981)	10(NR)	13.78	Intellectually disabled	WISC; FIQ = 61.20 (14.17)	Rutter (1971)	Clinical Assessment	9(NR)	Intellectually Delayed (non-ASD)	Age and intellectual functioning	Verbally prompted to pose facial expressions	Expression Quality	1	-.776

Study (date)	ASD group characteristics						Comparison group		Group Matching	Task in Which Facial Expressions were Observed	Outcome Variables	N of ES	ES
Legiša et al. (2013)	8(NR)	11.00	Normal range	WISC; FIQ Mean and SD not reported. Range = 75-89	DSM-IV	CARS	8(NR)		Age only	Spontaneous expression from exposure to pleasant and unpleasant odors	Expression Quality	3	-2.354
											Intensity		-.183
											Reaction Time		-.871
Li et al. (2011)	42(3)	2.00	Not reported	Not Applicable	DSM-IV	ABC, CARS	42(3)	TD	Intellectual functioning only	Spontaneous expression from viewing images of woman smiling	Intensity	1	.190
Loveland et al. (1994)	18(4)	12.26	Intellectually disabled	MSCA/PPVT or LIPS; VMA = 5.66 (1.98), NVMA = 6.89 (1.88)	Not reported	CARS	24(16)	Down Syndrome	Age and intellectual functioning	Verbally prompted to pose facial expressions or imitate researchers' expressions	Expression Quality	3	-2.009
											Intensity		-.276
											Voluntary Expression Accuracy		-.646
MacDonald et al. (1989)	10(0)	27.2	Normal Range	BPVS or RSPMT; VIQ = 84.1 (27.6), PIQ = 118.4 (13.0)	Rutter (1978), ICD-10	Clinical Assessment	10(0)	TD	Age only	Verbally prompted to pose facial expressions	Expression Quality	2	-1.459
											Voluntary Expression Accuracy		-1.265
Magnée et al. (2007)	13(0)	21.50	Normal Range	WAIS; FIQ = 122.4 (9.2)	DSM-IV	ADOS, ADI-R	13(0)	TD	Age and intellectual functioning	Automatic mimicry of emotional facial expression images	Automatic Mimicry Accuracy	1	.275
Markodimitraki et al. (2013)	10(1)	5.42	Not reported	Not applicable	Not reported	Previously diagnosed	10(4)	TD	Not reported	Spontaneous expression during imitated action tasks	Frequency/ Duration	1	-2.369
Mathersul et al. (2013a)	18(4)	44.60	Normal range	WASI; FIQ = 117.4 (10.0)	DSM-IV-TR	RAADS	18(5)	TD	Age and intellectual functioning	Spontaneous expression in response to emotionally arousing or neutral images	Intensity	1	-.095
Mathersul et al., (2013b)	30(6)	41.70	Normal range	WASI; FIQ = 112.9 (16.0)	DSM-IV-TR	RAADS	31(7)	TD	Age and intellectual functioning	Automatic mimicry of emotional facial expression images	Automatic Mimicry Accuracy	1	-.959
McGee et al. (1991)	5(0)	4.25	Intellectually disabled	SBIT or KABC; FIQ = 70 (SD not reported)	DSM-III-R	Non-specified researcher assessment	5(3)	TD	Age only	Natural expression observed during normal preschool activities	Frequency/ Duration	2	.213
											Social Congruence		-3.068
McIntosh et al. (2006)	14(3)	27.00	Normal range	PPVT; VIQ = 101.1 (19.4)	DSM-IV	Previously diagnosed	14(3)	TD	Age and intellectual functioning	Automatic mimicry or voluntary imitation of emotional facial expression images	Automatic Mimicry Accuracy	3	-.778
											Frequency/ Duration		-.187
											Voluntary Expression Accuracy		-.367
Misailidi (2002)	16(3)	5.15	Intellectually disabled	SBIS; MA = 3.32 (1.05)	DSM-III-R or DSM-IV	Previously diagnosed	16(6)	TD	Intellectual functioning only	Natural expression during structured researcher-participant interaction	Frequency/ Duration	1	-.489
	13(0)	10.20	Normal range		Not reported	ADOS-G	13(0)	TD	Age only		Intensity	2	.039

Study (date)	ASD group characteristics						Comparison group		Group Matching	Task in Which Facial Expressions were Observed	Outcome Variables	N of ES	ES
Oberman et al. (2009)				WASI; FSIQ = 102.8 (17.3)						Spontaneous expression during an emotion recognition task of static facial images	Reaction Time		-.662
Press et al. (2010)	14(3)	14.22	Normal range	WAIS; FIQ = 114.4 (14.84)	Not reported	ADOS-G	14(2)	TD	Age and intellectual functioning	Verbally prompted to mimic emotional facial expression images	Reaction Time	1	.158
Reddy et al. (2002)	19(4)	27.00	Intellectually disabled	BSID; NVMA = 24.17 (10.37), VMA = 12.86 (7.06).	DSM-IV or ICD-10	Previously diagnosed	16(7)	Down Syndrome	Age and intellectual functioning	Natural expression during free play.	Frequency/ Duration	2	-.043
											Social Congruence		-.544
Rozga et al. (2013)	17(5)	16.60	Normal range	WASI; VIQ = 103.1 (15.5), PIQ = 101.8 (22.0)	Not reported	ADOS, ADI-R	17(5)	TD	Intellectual functioning only	Automatic mimicry in response to clips of faces displaying facial expressions with corresponding affective prosody.	Automatic Mimicry Accuracy	1	-.580
Schulte-Rüther et al. (2017)	18(0)	16.34	Normal range	WISC; FIQ = 105.85 (14.87)	DSM-IV and ICD-10	ADOS, ADI-R	18(0)	TD	Age and intellectual functioning	Spontaneous expression while viewing dynamic audio-visual stimuli during an emotion recognition task.	Reaction time	1	.374
Smith (2007)	54(4)	9.50	Normal range	WISC; FIQ = 99.19 (15.80)	DSM-IV-TR	Previously diagnosed	42(2)	TD	Age and intellectual functioning	Verbally prompted to pose facial expressions	Expression Quality	2	-.522
											Voluntary Expression Accuracy		-.186
Snow et al. (1987)	10(1)	3.33	Intellectually disabled	GSE; MA = 2.25 (8.85)	DSM-III	Previously diagnosed	10(1)	Intellectually Delayed (non-ASD)	Age and intellectual functioning	Natural expression during naturalistic play setting	Frequency/ Duration	2	-1.232
											Social Congruence		-3.241
Stagg et al. (2014) Exp. 1	4(2)	11.50	Not reported	Not applicable	Not reported	Previously diagnosed	4(2)	TD	Age only	Spontaneous expression while telling positive and negative life stories.	Frequency/ Duration	2	-.052
											Intensity		-.863
Stel et al. (2008) Exp. 1	8(NR)	14.65	Not reported	Not applicable	Not reported	Previously diagnosed	21(NR)	TD	Age only	Automatic mimicry while watching video of someone describing positive events.	Automatic Mimicry Accuracy	1	-.196
Stel et al. (2008) Exp. 2	33(NR)	14.19	Not reported	Not applicable	Not reported	Previously diagnosed	28(NR)	TD	Age only	Automatic mimicry or voluntary imitation while watching video of someone describing positive events or	Automatic Mimicry Accuracy	2	-1.097
											Voluntary Expression Accuracy		-.096
	20(3)	14.45	Normal range		DSM-IV		19(6)	TD	Age only		Intensity	2	-.396

Study (date)	ASD group characteristics						Comparison group		Group Matching	Task in Which Facial Expressions were Observed	Outcome Variables	N of ES	ES
Sterling et al. (2013)				DAS; VIQ = 102.15 (19.08), PIQ = 106.85 (15.11)		ADOS, ADI-R (at time of study or within last 3 years)				Spontaneous expression from exposure to startling air puffs and auditory stimuli	Reaction time		-.108
Tantam et al. (1993) Exp. 1	9(2)	24.00	Normal range	WISC; VIQ = 105.4 (13.2), PIQ = 98.6 (19.6)	Wing & Gould (1979) or Rutter (1978)	Historical clinical information, unspecified questionnaires	9(NR)	TD	Not reported	Spontaneous expression during conversation with someone they just met.	Frequency/ Duration	2	-1.060
											Social Congruence		-.403
Tantam et al. (1993) Exp. 2	6(0)	26.8	Normal range	WISC; VIQ = 105.4 (13.2), PIQ = 98.6 (19.6)	Wing & Gould (1979) or Rutter (1978)	Historical clinical information, unspecified questionnaires	6(0)	Schizoid personality disorder	Age and intellectual functioning	Spontaneous expression during conversation with someone they've just met.	Frequency/ Duration	2	.051
											Social Congruence		-.977
Trevisan et al. (2016)	17(4)	10.21	Normal range	WASI; FSIQ = 107.00 (30.46)	DSM-IV-TR	Previously diagnosed	17(4)	TD	Intellectual functioning only	Spontaneous expression while watching emotionally arousing videos	Frequency/ Duration	1	.083
Volker et al. (2009)	42(2)	9.17	Normal range	WISC; FSIQ = 100.50 (16.25)	DSM-IV-TR	Previously diagnosed, researchers reviewed clinical information	42(2)	TD	Age only	Verbally prompted to pose facial expressions	Expression Quality	2	-.649
											Voluntary Expression Accuracy		-.186
Ward (1996)	10(1)	4.78	Intellectually disabled	PPVT; VIQ = 34.8 (9.27)	Not reported	Previously diagnosed, confirmed by "chartered psychologist"	10(1)	TD	Intellectual functioning only	Natural expression during free and structured play	Frequency/ Duration	2	.021
											Social Congruence		-2.138
Yirmiya et al. (1989)	18(4)	4.44	Intellectually disabled	CIIS or SBIS; MA = 2.14 (0.76)	DSM-III	CARS	18(4)	TD	Intellectual functioning only	Natural expression during structured play	Expression Quality	2	-.961
											Frequency/ Duration		-.525
Yoshimura et al. (2015)	15(3)	26.2	Normal range	WAIS; FSIQ = 111.4 (17.5)	DSM-IV-TR	CARS	15(6)	TD	Age and intellectual functioning	Automatic mimicry or voluntary imitation in response to static facial expression images	Automatic Mimicry Accuracy	3	-.494
											Frequency/ Duration		-.052
											Intentional Expression		-.525

Note. ABC = Autism Behavior Checklist, ADOS = Autism Diagnostic Observation Schedule, ADI-R = Autism Diagnostic Interview – Revised, BPVS = British Picture Vocabulary Scale; CARS = Childhood Autism Rating Scale, CIIS = Cattell Infant Intelligence Scale; DAS = Differential Ability Scales; DSM = Diagnostic and Statistical Manual of Mental Disorders, ES = Effect Size; FIQ = Full-scale Intelligence Quotient; GSE = Gesell Developmental Examination; ICD = International Statistical Classification of Diseases and Related Health Problems, KABC = Kaufman Assessment Battery for Children; K-BIT = Kaufman Brief Intelligence Test; LIPS = Leiter International Performance Scale; MA = Mental age; MCSA = McCarthy Scales of Children's Abilities; NVMA = Nonverbal mental age; PIQ = Performance Intelligence Quotient; PPVT = Peabody Picture Vocabulary Test, RSPMT = Raven's Standard Progressive Matrices Test; RAADS = Ritvo Autism Asperger Diagnostic Schedule; RDLS = Reynell Developmental Language Scales; SBIS = Stanford-Binet Intelligence Scale; VMA = Verbal mental age; VIQ = Verbal Intelligence Quotient; WASI = Wechsler Abbreviated Scale of Intelligence; WAIS = Wechsler Adult Intelligence Scale; WISC = Wechsler Intelligence Scale for Children. The column labeled N(f) refers to the sample size of the study with the number of females within the total sample in parentheses.

2.3.2. Summary of Effects by Outcome Variable

For my first analysis, the 67 effect sizes summarized in Table 2.3 were categorized according to outcome variable. In table 2.4, effect sizes representing the strength of ASD-comparison group differences and other descriptive information for each of the seven outcome variables are reported. Significant ASD-comparison group differences were observed for five of the seven outcome variables in the expected direction such that ASD participants displayed facial expressions with less Frequency/Duration, lower Expression Quality, poorer Voluntary Expression Accuracy, less Automatic Mimicry Accuracy, and poorer Social Congruency. Non-significant ASD-comparison group differences were found for two of the seven outcome variables—Intensity and Reaction Time. Of the five significant outcome variables, the ASD-comparison group differences for Expression Quality and Social Congruency can be interpreted as large effects, whereas the group differences for Frequency/Duration, Voluntary Expression Accuracy and Automatic Mimicry Accuracy can be interpreted as small to moderate effects. Negative effect sizes (see Hedge's *g* column) indicate lower scores in the ASD group.

Table 2.4. Group Differences Between ASD and Comparison Groups for each Outcome Variable.

	k	ASD n	Expected ES Direction	Hedge's *g*	SE	*p*-value	95% CI	
							Lower	Upper
Intensity	9	152	Negative	-.063	.078	.419	-.215	.089
Frequency/Duration	18	259	Negative	-.384	.159	.016	-.696	-.073
Expression Quality	11	213	Negative	-1.028	.153	<.001	-1.327	-.728
Voluntary Expression Accuracy	9	204	Negative	-.330	.092	<.001	-.511	-.150
Automatic Mimicry Accuracy	7	145	Negative	-.553	.177	.002	-.900	-.206
Social Congruency	8	93	Negative	-1.265	.339	<.001	-1.929	-.601
Reaction Time	5	73	Positive	.087	.194	.653	-.293	.468

Note. Hedge's *g* = strength of effect, CI = confidence interval, SE = standard error, k = number of effects, n = sample size, ES = effect size

2.3.3. Results of Moderator Analyses

Next, I calculated an overall summary effect size in which all 39 studies were combined, regardless of outcome variable. This variable represents an overall summary of ASD-comparison group differences in facial expressions and was calculated mainly to examine whether it would be appropriate to conduct subsequent moderator analyses. The directionality of effects subsumed under the 'Reaction Time' variable was reversed to remain consistent with the directionality of effects of all other outcome variables. In many cases, multiple effect sizes contributing to separate outcome variables were reported from within one study. In such cases, effect sizes were averaged into one effect size per independent sample to maintain statistical independence (Borenstein et al., 2009). Across all 39 studies, the overall summary effect size representing the average ASD-comparison group differences in facial expressions is g = -.481, p < .001, indicating a moderate effect size. Dispersion statistics revealed that Q(38) = 138.198, p < .001, and I^2 = 72.503, indicating that the heterogeneity of effect size strength among the 39 studies is statistically significant. The I^2 statistic indicates that 72.5% of between-studies variance can be explained by study-level covariates and that only 27.5% of the variance was within-study variance due to sampling error. These statistics indicate substantial variability among effect sizes necessitating further moderator analyses to identify the study-level covariates that contribute to this variability. The moderating effects of facial expression elicitation strategies, matching procedures, intelligence and age are reported in the following paragraphs. As random effects models tend to overestimate the sampling error variance of small studies, I followed the recommendations of Borenstein et al. (2009) to use the less stringent fixed effects model when conducting moderator analyses with small sample sizes to maximize statistical power.

Facial Expression Elicitation Strategies

Facial expression elicitation strategies were coded into 2 categories, 'covert elicitation' or 'explicit elicitation.' The between levels-difference among the categories was statistically significant, $Q_B(1)$ = 6.194, p = .013. The effect for explicit elicitation was (g = -.161, p = .015, df = 8), whereas the effect for covert elicitation was (g = -.384, p < .001, df = 24). In short, across all outcome variables, facial expression differences between ASD and control groups were larger for covertly-elicited facial expressions compared to explicitly-elicited facial expressions.

Chronological age

The moderating effect of the ASD group's age was analyzed as a continuous variable using meta-regression. This effect was statistically significant such that ASD-comparison group differences became smaller as average age of the ASD samples increased, $Q = 135.77$, $p < .001$, $df = 37$, $R^2 = 0.15$.

Intellectual Functioning

Regardless of matching procedures, intellectual functioning of the ASD group was coded into three categories based on how the original authors from each study characterized their sample; 'normal range,' 'intellectually impaired' or 'not clearly reported.' The between-levels differences was statistically significant, $Q_B(2) = 23.924$, $p < .001$. Group differences were strongest for intellectually impaired individuals with ASD ($g = -.730$, $p < .001$, $df = 9$), with minimal group differences observed for groups in the normal intellectual functioning range ($g = -.198$, $p < .001$, $df = 21$). For studies in which intellectual functioning was not obtained or not clearly reported, group differences were also strong ($g = -.664$, $p < .001$, $df = 6$). These findings suggest that deficits in facial expressions are most pronounced for intellectually impaired individuals with ASD.

Matching Procedures

Matching procedures were coded into four categories, 'age + intellectual functioning,' 'age only,' 'intellectual functioning only' and 'not clearly reported.' There were only two studies in which matching procedures were not clearly reported and were therefore not included in this moderator analysis. The between-levels differences among the categories was statistically significant, $Q_B(2) = 11.938$, $p = .003$. When studies matched participant groups on 'age + intellectual functioning,' group differences were statistically significant, but resulted in the weakest effect among the categories, ($g = -.176$, $p < .001$, $df = 16$), while 'age only' ($g = -.485$, $p < .001$, $df = 9$) and 'IQ only' ($g = -.487$, $p < .001$, $df = 9$) maintained moderate effects. This pattern suggests that the most stringent matching procedures yield the weakest effects.

2.4. Discussion

2.4.1. Summary of Findings

Findings from this meta-analysis demonstrate that there are a variety of differences in how people with ASD display facial expressions across a wide array of naturalistic and laboratory settings. Studies that quantified frequency or duration of facial expressions found that relative to comparison participants, participants with ASD displayed facial expressions less often and for shorter periods of time. In addition, the facial expressions of individuals with ASD were less socially congruous, meaning that the facial expressions of individuals with ASD were less likely to be reciprocated or initiated for social communication purposes, or were more likely to be expressed in ways that seemed incongruous to the social context.

Large ASD-comparison group differences were also found in facial expression quality. Across studies, the facial expressions of participants with ASD are deemed as much more awkward, odd, unusual, mechanical, or otherwise irregular. Similarly, when prompted to intentionally pose facial expressions—either in response to verbal prompts (e.g., how do you look when you're sad?), or when being instructed to imitate a facial expression stimulus—individuals with ASD scored lower relative to comparison groups on measures that tapped the accuracy of voluntary facial expressions. Findings of inaccurate facial expressions extended to studies that examined the accuracy with which individuals with ASD automatically mimic facial expression stimuli in paradigms in which no instructions were given to participants to imitate the stimuli. Thus, in response to face stimuli, facial expression inaccuracy extends to both automatic mimicry and voluntary imitation of displays of facial expressions in ASD.

No reliable ASD-comparison group differences in the intensity of expression or reaction time to a stimulus were found. Many studies that examined intensity or reaction time invoked emotional arousal through the use of startling stimuli, emotional images, or disgusting odors. Other studies examined intensity from voluntary, posed expressions, where odd but "exaggerated" expressions were observed in participants with ASD (see, Faso et al., 2015), which also contributed to the null effects for intensity.

2.4.2 Moderator Analyses

The observed strength of ASD-comparison group differences observed in this synthesis were moderated by several methodological features, providing a more nuanced interpretation of the literature. Moderator analyses revealed a distinction between different facial expression elicitation strategies, reflecting that ASD-comparison group differences were larger for facial expressions that were *covertly* elicited (g = -.384, $p < .001$) compared to facial expressions that were *explicitly* elicited (g = -.161, $p = .015$). In essence, it appears that individuals with ASD may naturally produce facial expressions differently from other populations but are less impaired in expressing emotions typically when prompted to do so in a laboratory setting (see also, Klin et al., 2002).

Results also revealed that participant age, intellectual functioning, and matching procedures based on age and intellectual functioning, significantly moderated the strength of ASD-comparison group differences. It was found that ASD-comparison group differences became smaller as age and intellectual functioning increased, suggesting that persons with higher intellectual functioning and larger accumulation of life experiences (due to age) are better able to produce facial expressions that are consistent with typical developmental norms. This pattern of results is consistent with longitudinal studies of children with ASD that indicate that emotional competencies increase over time and that intellectual functioning accelerates the magnitude of this progress (Dissanayake, Sigman, & Kasari, 1996; Seltzer, Krauss, Shattuck, Orsmond, Swe, & Lord, 2003). These findings were complemented by a separate analysis that found that the smallest ASD-comparison group differences were observed when participant groups were matched on both age and intellectual functioning, suggesting that the strength of ASD-comparison group differences may be exaggerated by the confounding effects of age or intellectual functioning, when participants were matched only on one or the other variable.

2.4.3 Implications for Social Functioning in ASD

Many theories of affective and social competence in the general population have emphasized the importance of being able to accurately *send* and *perceive* emotional signals for the purposes of facilitating social interactions (Halberstadt et al., 2001), and facial expressions represent an important channel by which humans send emotional signals. Therefore, it is worth considering how the atypical use of facial expressions in ASD may contribute to the broader social deficits characteristic of ASD. For example, the atypical visual appearance of facial expressions (described as awkward, odd or unusual), could significantly impact impression formation and the ease of social interactions (Faso et al., 2015). Moreover, central to the development of rapport and relationship-building is the ability to relate to others through the sharing of interests and affect. Therefore, findings from this study that participants with ASD are less likely to use facial expressions in socially congruous ways and less likely to mimic or imitate others' facial expressions likely contributes to social-emotional reciprocity deficits. Finally, successful social interactions are dependent on one's ability to understand, the thoughts, perspectives and emotions of one's interaction partner(s), and there is evidence to suggest that accurately mimicking or imitating another's facial expressions may aid the ability to infer others' emotions (Goldman & Sripada, 2005; Winkielman et al., 2009). As such, the finding that participants with ASD are less likely to mimic others' expressions (and do so less accurately) may contribute to the emotion recognition deficits that are common in the ASD population (Harms et al., 2010; Uljarevic & Hamilton, 2013), and future research may benefit from examining whether these skillsets overlap in the ASD population. Overall, findings from this study offer compelling evidence that atypical use of facial expressions in individuals with ASD is a major component of the social communication and social interaction deficits characteristic of this population.

2.4.4 Limitations and Future Directions

This meta-analysis utilized a relatively small number of studies, which were categorized into even fewer numbers when separated according to outcome variable. Thus, the reliability of these effect sizes should be interpreted with caution and considered in light of the wide confidence intervals surrounding each effect size estimate (see Table 2.4). Moreover, the moderator analyses reported should be interpreted with caution because these statistically significant moderating effects were calculated using the less stringent fixed effects model, and because I had to collapse all studies across each outcome variable to maximize statistical power. Therefore, it is possible that the significant between-levels differences observed from these moderator analyses were confounded by the differing types of facial expressions, task demands and other methodological variables of each study. For example, when considering the finding that individuals with ASD were generally less impaired in explicitly-elicited versus covertly-elicited facial expressions, it is important to emphasize that the covert elicitation category lumped together several different paradigms including spontaneous facial expressions in response to stimuli such as startling noises or odors, automatic mimicry in response to facial expression stimuli, and spontaneous expressions during naturalistic interactions. This is potentially problematic in the sense that different types of facial expressions may rely on different mechanisms. For example, MNS impairment may be especially relevant for automatic mimicry (Dapretto et al., 2006), mentalizing impairments may be especially relevant for Voluntary Expression Accuracy (Baron-Cohen et al., 1985; Baron-Cohen, 2005), and alexithymia may be especially relevant for spontaneous expressions due to affective arousal (McDonald & Prkachin, 1990; Rasting et al., 2005; Troisi et al., 1996; Wagner & Lee, 2008). Therefore, more research is needed that utilizes a diverse array of methodologies and emotion-elicitation techniques that would allow the possibility to disentangle the effects of various task demands and other methodological features.

It is also worth mentioning that the moderator variable, *age*, was measured continuously using meta-regression, and that age among individual studies ranged from early childhood to adulthood. From a statistical standpoint, this large variance in age was a strength, in that it was possible detect how age moderated the strength of group differences across the lifespan. However, given the important differences in emotional abilities between pre-schoolers, adolescents, and adults, an alternative approach to treating the age variable would have been to categorize different age groups, and compare key findings across these three groups which may have generated more generalizable findings with respect to age. Ultimately, it was decided not to do so, as categorizing a continuous variable would result in even lower statistical power for an already under-powered analysis.

Another key limitation is an inattention to sex differences in this study. This may have been a particularly important moderating variable, given well-known differences in the social behavior of males compared to females on the autism spectrum (Attwood, 2007; Gould & Ashton-Smith, 2011; Kopp & Gillberg, 2011). Given best estimates suggesting that ASD is diagnosed in males approximately four to five times more often than in females (Fombonne, Quirke, Hagen, 2011), and given the small sample sizes typically utilized in ASD research, researchers rarely reported sex or gender differences in the studies reviewed in this meta-analysis. Indeed, Table 2.3 shows that the total sample size of females with ASD ranged only from 0-6 across all studies. As meta-analysts can only analyze data that were reported in the original studies, this lack of reporting in sex differences made it impossible to analyze sex as a moderator variable in this study. This remains an important empirical question for future research, as the female phenotype of autism remains severely under-researched (Philip, Dauverman, Whalley, Baynham, Lawrie, & Stanfield, 2012; Via, Radua, Cardoner, Happé, & Mataix-Cols, 2011), as it is possible that the under-diagnosis of females with ASD (Lai, Lombardo, Auyeung, Chakrabarti, & Baron-Cohen, 2015) may be due in part to more socially competent or typical use of facial expressions and other forms of nonverbal communication in females.

This synthesis is the first to systematically review the existing literature on facial expression production in ASD and helps clarify some of the equivocal findings in the literature regarding a) which aspects of facial expressions are impaired or intact in ASD and b) the methodological variables that influence the strength of group differences between ASD and comparison groups. However, the research on facial expression production in ASD summarized in this meta-analysis has been almost exclusively motivated by an interest in characterizing group differences between ASD and non-ASD comparison groups. Thus, there has been little consideration for the mechanisms that may contribute to abnormal facial expressions observed in ASD. This should be a focus of future research. For example, several studies reviewed in Chapter 1 found that alexithymia was associated with less spontaneous facial expression in the general population and in non-ASD clinical groups. This finding suggests that difficulties understanding one's own emotions may negatively impact abilities to spontaneously *communicate* emotions nonverbally via facial expressions. Given the significantly heightened rates of alexithymia in ASD compared to the general population in both children and adults (Hill et al., 2004; Griffin, Lombardo & Auyeung, 2016), alexithymia may play a significant role in atypical facial expression in ASD. Therefore, Chapter 3 will explore the potential link between alexithymia and reduced spontaneous expression in children with ASD, and Chapter 4 will examine potentially distinct correlates of spontaneous expressions (i.e., spontaneous expression while telling emotional stories or watching emotional video clips) and voluntary expressions (i.e., voluntarily posed expressions in response to experimental prompts) to gain a more sophisticated understanding of how alexithymia and ASD traits may differentially be related to spontaneous and voluntary expressions.

Chapter 3.

Alexithymia, not ASD Traits, is Associated with Duration of Spontaneous Facial Expressions in Response to Emotional Video Clips

A version of this chapter has been published elsewhere: Trevisan, D. A., Bowering, M., & Birmingham, E. (2016). Alexithymia, but not autism spectrum disorder, may be related to the production of emotional facial expressions. Molecular autism, 7(46), 1-12.

3.1. Introduction

Because research on atypical facial expression production in ASD has almost exclusively been motivated by an interest in finding group differences between ASD and TD participants, there is little known about how this clinical feature of ASD emerges, or how to explain heterogeneity of facial expression abilities within the ASD population. The diagnostic criteria of ASD includes different fine-grained subdomains of social interaction and social communication difficulties such as “reduced sharing of emotions,” “poorly integrated verbal and nonverbal communication,” and in some cases a “total lack of facial expressions” (APA, 2013). These descriptions are consistent with the robust empirical differences in facial expression production between individuals with ASD and non-ASD comparison groups summarized in the meta-analysis in Chapter 2. However, many individual studies included in the meta-analysis failed to find group differences on various facial expression abilities, and it is possible that participant-level characteristics may be accounting for mixed results. For example, I found in Chapter 2 that both age and intellectual functioning of the ASD groups moderated the strength of ASD-comparison group differences. In the present study, another characteristic that may explain facial expression heterogeneity within the ASD population (alexithymia) will be examined.

The alexithymia hypothesis posits that, when present, high levels of alexithymia may be accounting for heterogeneity in certain social-emotional deficits associated with ASD (Bird & Cook, 2013). The prediction that alexithymia may account for heterogeneity in atypical facial expression production in ASD emerges from a body of research reviewed in Chapter 1 which generally found that higher levels of alexithymia is associated with less frequent and less salient spontaneous displays of affect (McDonald & Prkachin, 1990; Rasting et al., 2005; Troisi et al., 1996; Wagner & Lee, 2008; cf; Luminet et al., 2004; Roedema & Simons, 1999), although this link has yet to be examined in ASD. An untested prediction that follows is that the reduced displays of affect characteristic of ASD may be explained in part by heightened levels of alexithymia in this population.

To test this link, the present study examined whether alexithymia contributes to reduced production of facial expression in response to emotionally charged video clips in children with and without ASD. This method was chosen because ASD is associated with social communication and social interaction deficits (APA, 2013), and therefore it was necessary to assess facial expressions in a "non-social" task so that social deficits characteristic of ASD would not confound the results of the study. Because participants watched the video clips by themselves and their facial expressions were covertly recorded, any observed facial expressions are a) presumably due to authentic affective arousal and b) did not serve any social or communicative purposes.

3.2. Methods

3.2.1. Participants

Thirty-four children—17 with an ASD diagnosis and 17 TD comparisons—participated in this study. There were an equal number of boys and girls in each group. Participants were matched on IQ as measured by the Vocabulary and Matrix Reasoning subtests of the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999), although the groups differed marginally on chronological age (see Table 3.1). Participants were recruited for one of two 1-day summer camps hosted by the Autism and Developmental Disorders Lab (ADDL) at Simon Fraser University (SFU). These day camps were designed to engage children in fun and educational activities related to social sciences, with dedicated time set aside for data collection. On subsequent Saturdays during the summer of 2015, identical camps were hosted; one for children with a diagnosis of ASD and one for TD children. Participants were recruited via a number of different methods. Email announcements of the camp were distributed to private and public schools in the area and participants from the ADDL participant database were notified. In addition, information about the camps was posted on community websites, and fliers were posted on community billboards near SFU and surrounding cities.

Participants were admitted into the ASD-specific camp only if their parents provided proof of diagnosis. All participants with ASD had received a standardized clinical diagnosis of ASD from a qualified pediatrician, psychologist, or psychiatrist associated with the provincial government-funded autism assessment network, or through a qualified private clinician. All diagnoses were based on the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR; APA, 2000) and confirmed using the Autism Diagnostic Interview–Revised (ADI-R; Rutter, Le Couteur, & Lord, 1994) and/or the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000). The province of British Columbia (BC), in which this study was conducted, has instituted standardized diagnostic practices for a diagnosis of ASD as the diagnosis is tied directly to government funding.

3.2.2. Materials

Video Stimuli

Participants viewed a collation of ten short video clips from various children’s movies, documentaries, and home videos uploaded to Youtube.com. The clips were selected to produce a wide range of emotional reactions (see details of clips in Appendix A). Clips were separated by a 5-second blank screen. The entire video was 712 seconds (approximately 12 minutes) long.

Alexithymia

Alexithymia was assessed using the Children’s Alexithymia Measure (CAM), a parent-report measure designed to assess early childhood indicators of alexithymic tendencies (Way et al., 2010). The CAM consists of 14 items scored on a scale from 0 to 3. Total scores could range from 0 to 42, with higher scores representing higher levels of alexithymia. The CAM was validated in a sample of 224 parents of children who had experienced emotional trauma. Way et al. (2010) extensively validated the CAM by a) utilizing the expert opinion of several clinicians with expertise in childhood alexithymia to assess the face validity of an original item pool of 275 items, b) using a graded Item Response Theory model and factor analysis to identify items that load onto their theorized unidimensional factor structure demonstrating criterion-related validity, and c) demonstrating strong concurrent validity using theoretically related measures. The CAM's internal consistency reliability from the original validation study was high α = 0.92. To date, only one study (Griffin et al., 2016) has used the CAM for research within the ASD population, but they did not report reliability coefficients in their sample. The present study observed similar reliability coefficients to that of Way et al., (2010) for the full sample, α = 0.94, within the ASD group, α = 0.91, and within the TD group, α = 0.94. These findings suggest that the CAM is a reliable measure in both ASD and TD samples, although there is a need for future research to examine the validity of this measure in children with ASD (see section 3.4.2). A full list of the CAM's items are located in Appendix B.

ASD Traits

In addition to reporting formal diagnoses, parents of all ASD and TD participants completed the 50-item parent-report Autism Spectrum Quotient-Child Version (AQ; Auyeung, Baron-Cohen, Wheelwright, & Allison, 2008) so that ASD traits could be assessed continuously. The AQ is scored on a range from 0 to 50, with higher scores indicating higher levels of ASD traits. This measure is a screening tool and is used primarily for research purposes. The AQ assesses social and non-social characteristics of autism relating to social skills, communication skills, attention to detail, imagination, and tolerance of change. In the original validation study, Auyeung et al., (2008) reported strong internal consistency reliability for the AQ among a large sample of 1,417 combined TD and ASD children (ASD n = 192), α = 0.97. In this sample, slightly lower reliability coefficients were found for the full sample, α = 0.87, within the ASD group, α = 0.83, and within the TD group, α = 0.86. A full list of the AQ-Child Version items are located in Appendix B.

Intelligence

Intelligence was estimated with the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999), which includes two subtests of nonverbal intelligence (Block Design and Matrix Reasoning) and two subtests of verbal intelligence (Vocabulary and Similarities). Due to time constraints of the camp, only the Vocabulary and Matrix Reasoning subtests were administered. The Vocabulary subtest assesses abilities related to word knowledge and verbal concept formation by testing participants' ability to provide word labels for objects presented to them, and their ability to provide definitions of words that are presented visually and orally. The Matrix Reasoning subtest assesses abilities related to spatial reasoning, fluid intelligence, and perceptual organization by requiring participants to view a series of incomplete matrices and complete them by selecting the correct response option. In the WASI technical manual, internal consistency reliabilities are not available for clinical samples. Internal consistency reliabilities for the Matrix Reasoning subtest in TD children aged 7-13 range from $\alpha = 0.85$ to 0.88 (Wechsler, 2011). For the Vocabulary subtest, the internal consistency reliabilities for TD children aged 7-13 range from $\alpha = 0.90$ to 0.93 (Wechsler, 2011).

Facial Expression Analysis Technology

Facial expressions were analyzed using iMotions' facial expression analysis technology called "FACET" (available from https://imotions.com, 2016), which uses the facial action coding system (FACS; Ekman & Friesen, 1978; Ekman, Friesen & Hager, 2002) to estimate the degree to which emotional facial expressions are being expressed at any given time frame (i.e., $1/30^{th}$ of a second). The software takes a singular 'snapshot' of the video image once per frame and generates numerical output for each frame indicating the probability that facial expressions are present. These probabilities are estimated based on a library of expert human coders who have coded thousands of facial stimuli to train the FACET algorithm. The FACS system estimates the presence or absence of emotions based on the relationships and movements among 28 main action units in the face with additional descriptors based on subtle head movements and gross movement behaviors. The FACET software currently tracks 21 facial action channels to estimate the probability that each of several basic emotions (joy, sadness, anger, fear, disgust, surprise, and contempt) are present based on comparisons between the location of action units at baseline (participants' neutral expression) and the location of action units while participants are displaying facial expressions. While FACET requires an extensive validation study, its academic predecessor, the Computer Expression Recognition Toolbox (CERT) from which FACET's technology was derived, has demonstrated strong psychometric properties as evidenced by its ability to correctly detect emotions from standardized facial expression stimuli (Littlewort et al., 2011).

For the purposes of the present study, I analyzed FACET output indicating the proportion of total time (i.e., the combined total of frames) that *negative* (which could represent any negative emotion ranging from anger, fear, surprise, sadness, disgust and contempt, *positive* (includes expressions of joy), and *neutral* (no emotional expression) facial expressions were identified by the FACET software. For example, the expert human coders who trained FACET to identify emotions would have coded facial expressions as "negative" anytime they deemed an expression as containing elements of a negative emotion (i.e., facial muscle movements that represent of disgust, anger, fear, sadness, or contempt.). Each of these variable categories are calculated simultaneously and independently by FACET, such that any combination of emotions can be detected at any given time point. For example, while watching the movie character, Shrek, brush his teeth with the guts of a worm he squeezed onto his toothbrush (see Appendix A), participants may respond to the clip with both joyful and disgusted facial expressions—thus, negative and positive expression may be detected at the same time. In addition to detecting expressions of negative and positive emotions, FACET also usually detects neutral when emotional expressions are not very intense. FACET reports the probability that each of these emotional categories are expressed using a base 10 logarithmic likelihood estimate. For example, a positive threshold value of -1 (i.e., 10^{-1}) indicates a probability of 10:1 that positive emotion is *not* being expressed, whereas a value of 2 (i.e., 10^{2}) indicates a probability of 100:1 that positive emotion *is* being expressed. Within the iMotions interface, researchers have the opportunity to set their own threshold values for FACET. Threshold values that are too lenient may overestimate the amount of emotions being expressed, and vice versa. In addition, threshold values that are too low or too high can lead to abnormal distributions of scores yielding too many participants scoring at or near baseline or ceiling. Based on the recommendations of an iMotions representative (A. Viramontes, personal communication, October 26, 2015), the threshold value was set at 0.5, which translates to a probability of $10^{.5}$ (roughly 3.16:1). As research questions and methods used to elicit facial expressions vary substantially among different studies, there is no "standard" threshold used across all research studies that utilize FACET. This threshold value was recommended based on A. Viramontes' prior experience that 0.5 thresholds are sensitive enough to detect subtle facial expressions in response to video stimuli, but would not be overly sensitive either (thereby avoiding floor or ceiling effects). The dependent variable was the percentage of time participants expressed various emotions during the 712-second video. Thus, a negative percentage value of 22% can be interpreted as "negative expression was expressed at least 3.16 times more likely than not during 22% of the video."

3.2.3. Procedure

Before the camp, parents completed and submitted forms and questionnaires for research and camp purposes, including those analyzed in the present study. Simon Fraser University's institutional Research Ethics Board approved all experimental tasks conducted as part of the camp and parents were informed of the details of each research task. Parents were not required to consent to all aspects of the research procedures in order for their children to participate in the camp. For example, eight parents consented to have their children participate in the research tasks but did not approve videotaping of their children. In such cases, children still participated in the research tasks, but their facial expressions were not recorded with a webcam and therefore not analyzed in the present study (Table 3.1 and all analyses exclude all such participants).

All experimental data were collected during camp activities. The camp was separated into seven different sessions during a six-hour period (with lunch and other breaks throughout). Each session lasted approximately 40 minutes. The present study was included in a session along with another research activity (unrelated to the present study). As such, 20 minutes of the session was devoted to the present study. Groups of four to seven participants completed the task at one time, with participants separated by cardboard dividers to prevent distraction. Each participant watched the video clips (presented using Quicktime Player 10.4) on their own laptop computer (13 or 11" MacBook running OSX 10.11.3) with headphones. Participants' facial expressions while watching the clip were covertly recorded with a built-in webcam.

3.3. Results

3.3.1. Group Differences on Demographic and Questionnaire Data

Group differences on IQ, age, sex and questionnaire data are reported in Table 3.1. The ASD group scored significantly higher than the TD group on the AQ and CAM, but there were no group differences in verbal or nonverbal intelligence as measured by the WASI. The ASD group was also older than the TD group at a statistically significant level.

Table 3.1. Means, Standard Deviations, Ranges and Group Differences of Participant Characteristics

	ASD (n = 17)	TD (n = 17)	*p*-value
Sex Ratio M:F	13:4	13:4	--
Age	10.21 (1.78), 7.0–13.1	8.97 (1.30), 7.0–11.5	.027
AQ	32.94 (8.85), 9–45	17.35 (9.61), 4–32	<.001
CAM	17.29 (8.55), 3-36	8.41 (8.88), 1-29	.006
WASI - Vocab	27.76 (10.65), 3–48	26.29 (7.00), 15–39	.637
WASI – Matrix	17.29 (5.30), 7–25	17.12 (5.21), 7–24	.923

Note. ASD = Autism Spectrum Disorder, TD = TD. AQ = Autism Quotient, CAM = Children's Alexithymia Measure, WASI = Weschler Abbreviated Scale of Intelligence. In the central columns, means are followed by Standard Deviations in parentheses, followed by Ranges.

3.3.2. Group Differences in Facial Expression Production

In Table 3.2 the results of three independent samples *t*–tests are reported comparing the ASD and non-ASD groups on how much emotion was expressed (measured by the percentage of time during the movie that an emotion category was detected at the .5 log likelihood criterion). No statistically significant differences were observed for positive, negative or neutral expression.

Table 3.2. Group Differences in the Proportion of Time that Emotional Expressions were Observed

	NT (n = 17) Mean (SD)	ASD (n = 17) Mean (SD)	*t*-value	*p*-value
Positive	11.41 (12.11)	8.41 (8.51)	-0.234	.409
Negative	47.81 (21.07)	60.19 (31.79)	1.339	.191
Neutral	68.06 (19.39)	78.06 (18.61)	1.534	.135

Note. The means for negative, positive and neutral emotion represent the percentages of time each emotion category was detected by FACET at the 10^{-5} threshold level.

3.3.3. Correlations Between Facial Expression Production, Demographic and Questionnaire Data

To examine the alexithymia hypothesis in the context of this study—that spontaneous facial expression production will be more strongly related to alexithymia than ASD traits—Pearson's *r* correlations within the ASD and TD samples were ran, as reported in Tables 3.3 and 3.4. The AQ, CAM and demographic variables were correlated with negative, positive and neutral expression. Intercorrelations among positive, negative and neutral variables revealed no statistically significant associations (all *p*s > .20), suggesting that they are each tapping into independent variables.

The coefficients presented in Tables 3.3 and 3.4 should be interpreted with caution because the analyses were severely underpowered. Power analysis suggested that to detect a moderate correlation of .30 with adequate power of .80 and an alpha level of .05, a sample size of 85 is recommended. Although not ideal, small sample sizes are common in clinical research given the difficulties involved in obtaining samples of clinical populations. The small sample sizes made it difficult to determine the normality of distributions for some of the variables. It is recommended that skewness and kurtosis values should fall within ±1.96 (Field, 2013), and most variables fell within this range. The one exception was AQ for the ASD group which had a kurtosis value of 2.48. Further inspection revealed that this non-normality was due to one potential outlier who had an AQ score of 9, much lower than the mean of 32.94. Removal of this outlier resulted in a skewness and kurtosis values that fell within the normal range of ±1.96. In addition, although the distribution of CAM scores for the TD group fell within the recommended skewness and kurtosis values, visual inspection revealed two or three potential outliers for the CAM in the TD group. To determine whether removal of these potential outliers would be appropriate, I used the default procedures of the Statistical Package for the Social Sciences (SPSS) for outlier detection. SPSS identifies extreme outliers by calculating the difference between the upper and lower quartiles of a boxplot and multiplying that difference by three (Tukey, 1977). Any scores exceeding the calculated product are considered extreme outliers. In no cases did any potential outliers violate this rule. Therefore, no data points were removed for subsequent analyses.

Distributions for negative, neutral and positive expression for both ASD and TD groups all fell within the normal range of ±1.96. However, visual inspection revealed some minor concerns of ceiling effects or bimodal distributions within some of these variables. Exploratory analyses were conducted to identify potential outliers using the rules stated above, and/or examine associations using other correlational methods such as Kendall's tau or Spearman's rho which are more robust to non-linear data. These exploratory analyses did not identify extreme outliers or change the statistical significance of correlation coefficients, and therefore are not discussed further.

Table 3.3. Intercorrelations Among Demographic and Facial Expression Variables for TD Sample

	1.	2.	3.	4.	5.	6.	7.	8.
1. CAM		.355	-.185	-.424	-.450	.333	-.557*	-.024
2. AQ			.196	-.156	-.074	.019	-.386	.278
3. Age				.586*	.371	-.113	-.204	-.080
4. Matrix					.186	.008	.097	-.107
5. Vocab						-.552*	.201	.347
6. Neutral							.012	-.208
7. Negative								.289
8. Positive								

Note. **Correlation is significant at the .01 alpha level (2-tailed). *Correlation is significant at the .05 alpha level (2-tailed). AQ = Autism Spectrum Quotient, CAM = Children's Alexithymia Measure, Age = Chronological age, Matrix = Matrix Reasoning subtest of Wechsler Abbreviate Scale of Intelligence (WASI), Vocab = Vocabulary subtest of WASI. Neutral, Negative, and Positive, represent the percentage of time these facial expression categories were detected by the FACET software. n = 17.

Table 3.4. **Intercorrelations Among Demographic and Facial Expression Variables for ASD Sample**

	1.	2.	3.	4.	5.	6.	7.	8.
1. CAM		.198	.010	.217	.015	.175	-.579*	-.149
2. AQ			-.069	.304	.046	.204	.038	-.251
3. Age				.649*	.537*	.371	.094	-.152
4. Matrix					.680*	.690**	-.107	-.148
5. Vocab						.609**	-.149	.121
6. Neutral							-.219	-.194
7. Negative								-.301
8. Positive								

Note. **Correlation is significant at the .01 alpha level (2-tailed). *Correlation is significant at the .05 alpha level (2-tailed). AQ = Autism Spectrum Quotient, CAM = Children's Alexithymia Measure, Age = Chronological age, Matrix = Matrix Reasoning subtest of Wechsler Abbreviate Scale of Intelligence (WASI), Vocab = Vocabulary subtest of WASI. Neutral, Negative, and Positive, represent the percentage of time these facial expression categories were detected by the FACET software. n = 17.

Results revealed partial support for the predictions that alexithymia would be more strongly related to facial expression variables than ASD traits. Consistent with this prediction, as Figures 3.1 and 3.2 show, alexithymia was negatively associated with negative facial expression production in response to the emotional video clips in both the ASD and TD samples. However, CAM scores were unrelated to neutral expression in both samples as the strength of the relationship did not reach statistical significance in either sample. CAM scores were also unrelated to positive expression at a statistically significant level. None of the correlations between the AQ and the facial expression variables were statistically significant for neutral, negative or positive expression in either sample.

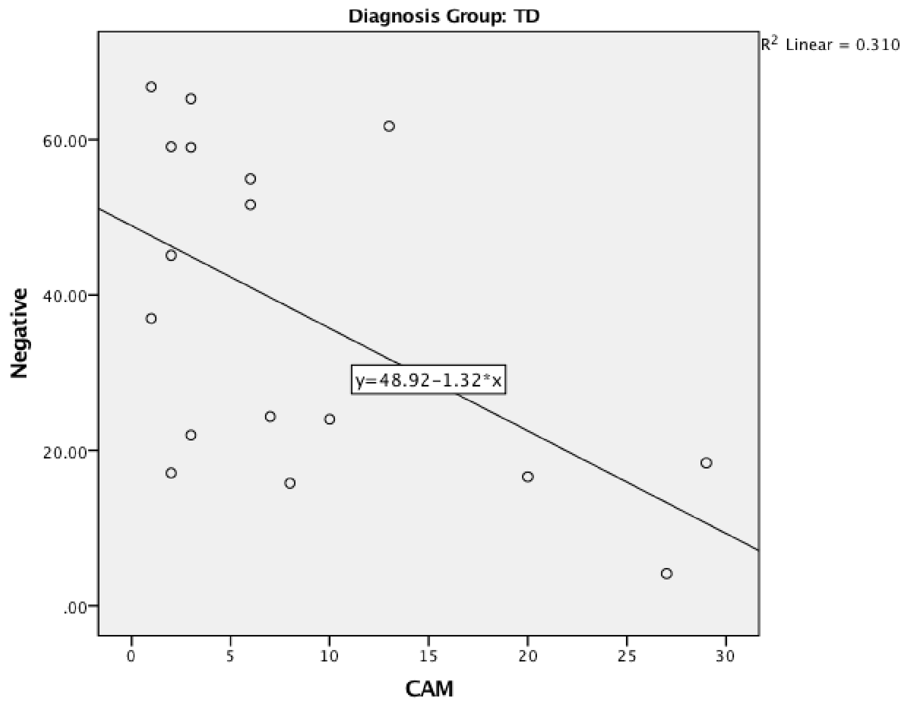

Figure 3.1. Scatterplot of Distribution of CAM and Negative expression in TD group.

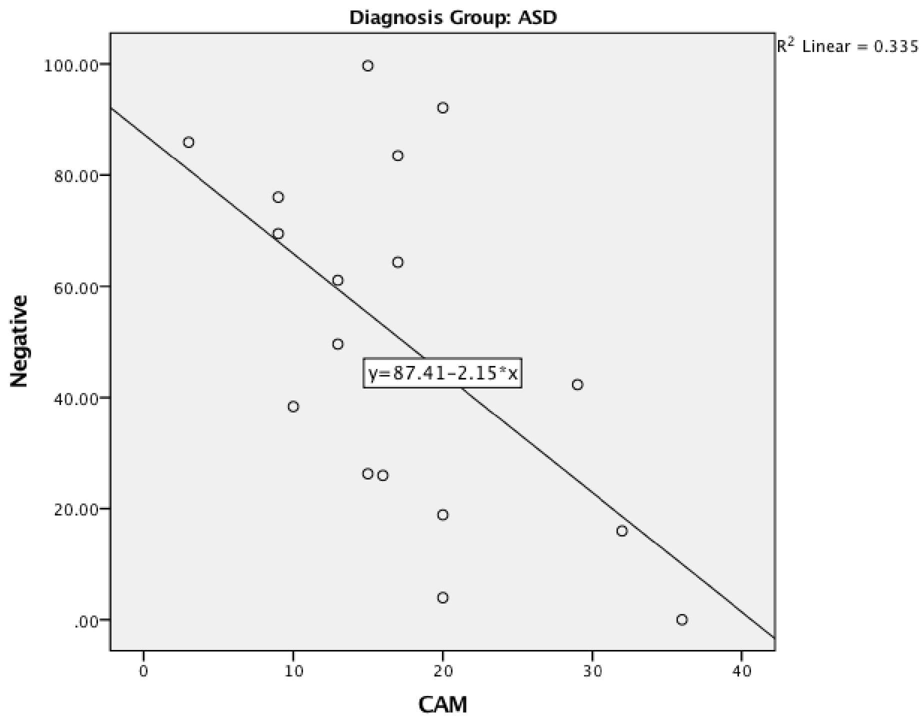

Figure 3.2. Scatterplot of Distribution of CAM and Negative expression in ASD group

To maximize statistical power, the original intent was to collapse both groups to run correlations among the whole sample following the procedures of Cook et al., (2013). Collapsing both groups would be justifiable if it was the case that the distributions of AQ and CAM scores overlapped significantly among the ASD and TD groups. However, visual inspection of a scatterplot correlating AQ and CAM traits across the whole sample reveals that this is not the case (at least for this sample). Figure 3.3 shows that there is very little overlap between either the AQ or CAM scores between the TD and ASD groups, such that the ASD participants tend to fall within the high ends of the distributions for both the CAM and AQ, and the TD participants tend to fall within the low ends of the distributions for both the CAM and AQ. Therefore, the decision was made not to collapse these groups because doing so could create spurious correlations that are due to diagnosis rather than true associations between variables of interest.

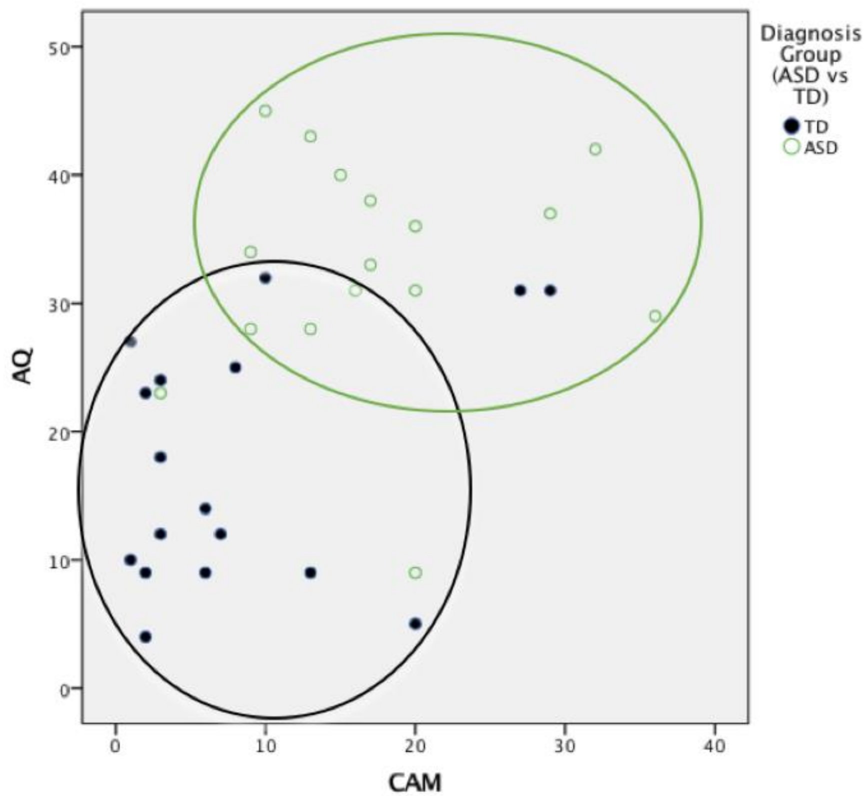

Figure 3.3. Scatterplot of distribution of AQ and CAM scores separate by ASD and TD groups.

3.4. Discussion

3.4.1. Summary of Findings

The main purpose of this study was to advance previous work on the 'alexithymia hypothesis,' extending this line of research to another component of emotion processing—emotional facial expressions. I examined the respective relationships of alexithymia and ASD traits on the production of spontaneous facial expressions in children with and without ASD as they watched emotionally salient video clips. Findings show that alexithymia was negatively associated with negative expression, but not with positive expression or neutral expression. In addition, ASD traits were unrelated to negative, positive and neutral expression at a statistically significant level. This pattern of results was consistent among two separate samples—one sample of children with ASD and one of TD children. This finding adds to a growing body of literature demonstrating that alexithymia seems to account for heterogeneity in emotion-related processing abnormalities in the ASD population (Bird & Cook, 2013). Results from this study also demonstrated large group differences in alexithymia between the ASD and TD participant groups in this sample, indicating that alexithymic traits are prevalent during childhood in individuals with ASD (see also, Griffin et al., 2016).

Why is alexithymia associated with less negative facial expression production in both children with and without ASD? One possibility is that highly alexithymic individuals may consciously suppress or subconsciously repress their own facial displays to defend against negative affect and to avoid interpersonal conflict (Fukunishi & Koyama, 2000; Rasting et al., 2005; Vingerhoets, Van Heck, Grim, & Bermond, 1995). Rasting et al. (2005) found that the expression of certain negative emotions, but not positive emotion, was correlated with alexithymia in patients with anxiety, depression and other disorders during an intake interview for a psychotherapeutic intervention. Similarly, Fukunishi and Koyama (2000) administered a battery of questionnaires to university students and found that alexithymia was associated with emotional instability, higher levels of state and trait anxiety, but also greater self-perceived emotional control. The authors suggested that individuals with alexithymia attempt to control (i.e., suppress) anger to stabilize their inner emotions. This explanation would suggest that alexithymic individuals might unconsciously suppress their unfavorable negative emotions such as anger or contempt to distance themselves from distressing inner emotions and to mitigate potential external conflict. Such a possibility would also predict the expression of non-distressing emotions (e.g., joy) to be unaffected by alexithymia. Data from this study support this notion, as I observed in this sample that higher alexithymic traits were associated with less negative expression, but not significantly associated with positive or neutral expression. However, it is possible that the nonsignificant associations between alexithymia and positive expression could have been attenuated due to the highly restricted variance in positive expression for both groups (see Table 3.2). This restricted variance may be due in part to positive expression only comprising one emotion (joy), whereas negative expression comprises a wider range of emotions. Thus, it is worthwhile to explore other potential explanations.

Given that alexithymia is associated with impaired interoceptive sensitivity in individuals with ASD (Shah et al., 2016), it may be that difficulties in emotional awareness (that stem from interoceptive difficulties) contribute to abnormal or diminished subsequent representation of these emotional states via facial expression or other motor indicators of emotion (Bird & Viding, 2014). Adding further complexity, there is evidence to suggest that the mere act of artificially producing facial expressions may generate an emotional experience in oneself (Levenson, Ekman, & Friesen, 1990) which could aid accuracy in perceiving one's own emotions. Thus, the relationship could be bi-directional such that alexithymia (perhaps via impaired interoception) could impair one's ability to produce facial expressions or that inaccurate or inhibited expression of emotion (e.g., facial expressions) could lead to difficulties identifying and describing one's own emotional states (i.e., alexithymia). These possible theoretical explanations will be explored in greater detail in the general discussion (Chapter 5).

These theoretical considerations may also help to explain the previously reported relationship between alexithymia and *emotion regulation* (Swart, Kortekaas, & Aleman, 2009). Not being consciously aware of one's emotions as they arise, actively suppressing one's emotions, or refusing to acknowledge that one is experiencing negative emotions would inhibit one's ability to regulate emotions as they increase in intensity—shedding light on the seeming paradox by which alexithymic individuals are prone to displaying minimal nonverbal emotional expression most of the time, but are also prone to sudden increases in emotional arousal or even emotional outbursts as distressing emotions increase in intensity (Berenbaum & Irvin, 1996; Haviland & Reise, 1996; Way et al., 2010). As emotion regulation issues—and ensuing emotional outbursts—are common in ASD (Mazefsky et al., 2013; Samson, Huber, & Gross, 2012; Jahromi, Meek, Over-Reynolds, 2012), future examinations of the 'alexithymia hypothesis' may find that alexithymia is a major contributor to emotion regulation difficulties in people with ASD. Support for this idea comes from research that shows that compared to TD comparisons, participants with ASD are more likely to use *suppression* (e.g., "*I keep my emotions to myself*" and "*When I am feeling negative emotions, I make sure not to express them*") as an emotion regulation strategy (Samson et al., 2012) as measured by the Emotion Regulation Questionnaire (ERQ; Gross & John, 2003). Thus, it appears that a relative disposition towards ignoring or suppressing one's emotions compounded by poor emotional insight (e.g., alexithymia) may contribute to emotion regulation problems in ASD (Mazefsky et al., 2013). Future research should explore how alexithymia and emotional suppression may impact near term emotional regulation difficulties (e.g., emotional outbursts) and long-term chronic emotion regulation disorders (e.g., depression and anxiety) which commonly afflict individuals with ASD (Mazefsky, et al., 2013; Simonoff, Pickles, Charman, Chandler, Loucas & Baird, 2008).

3.4.2. Limitations and Future Research Directions

Our sample size was small, limiting the power to detect moderate correlation coefficients or group differences in facial expression production. Indeed, no significant group differences in the proportion of total time facial expressions were detected for neutral, negative or positive expression between the ASD and TD groups. This null result was surprising given that the meta-analysis reported in Chapter 2 found that individuals with ASD tend to display facial expressions less often and for shorter duration across a range of several studies conducted in experimental and naturalistic settings. In light of the findings from this study that alexithymia was correlated with negative expression in both samples and that large group differences in alexithymia between the ASD and TD groups were found, from a statistical standpoint, it must be the case that variables unrelated to the aspects of facial expression production measured in the present study are accounting for the ASD-TD group differences in alexithymia in this sample. It has long been believed that individuals with ASD have difficulties with processing of their own and others' emotions (see Gaigg, 2012, for a review), so it is would not be surprising if many factors unrelated to nonverbal expression of emotion contribute to the strong ASD-comparison group differences on alexithymia reported here and elsewhere (e.g., Griffin et al., 2016; Hill et al., 2004).

It is also important to recognize that the Children's Alexithymia Measure (CAM) used in this study was validated in a sample of children who had experienced trauma (Way et al., 2010). Alexithymia has sometimes been categorized as "primary" or "secondary" alexithymia, based on unique etiologies. Whereas primary alexithymia may have a genetic component resulting also from neurological vulnerabilities and genetic disorders (Sifneos, 1983) such as ASD, secondary alexithymia results from environmental factors usually relating to psychological trauma (Krystal, 1988). As measurement tools are considered valid only in the population in which they're validated (Furr & Bacharach, 2013), it remains an important avenue for future research to examine whether primary and secondary alexithymia are qualitatively similar, and whether or not tools like the CAM are appropriate for use in the ASD population.

Another limitation of the present study is that only one aspect of facial expression was examined—the proportion of total time facial expressions were detected by FACET. Separate analyses from Chapter 2 demonstrated that in addition to less frequency and duration, ASD facial expressions are also rated as significantly lower in "quality" (e.g., rated as more awkward, bizarre or confusing), and are expressed with less "accuracy" (i.e., more difficult for others to infer the intended emotional meaning). Thus, even when facial expressions are not absent or reduced in persons with ASD relative to TD groups as was the case in this study, there may be qualitative differences on how facial expressions are produced that were not directly assessed in the present study. Thus, one of the foci of Chapter 4 is to examine correlates of other aspects of facial expression production. Findings from this study and other similar studies suggest that within TD and ASD samples, individuals with higher levels of alexithymia may suppress or repress nonverbal emotional displays as a strategy to defend against negative affect and avoid interpersonal conflict. However, the tendency of highly alexithymic individuals to spontaneously suppress the display of negative emotions does not imply an *inability* to produce facial expressions (McDonald & Prkachin, 1990). Therefore, it is unclear whether alexithymia is associated with the ability to accurately produce voluntary negative or other facial expressions on command. The ability to pose facial expressions likely relies, at least in part, on mentalizing abilities (e.g., awareness of what information is needed by the observer to infer the intended emotional meaning) which are believed to be impaired in ASD (Baron-Cohen et al., 1985; Baron-Cohen, 1995, 2005). Thus, in contrast to a natural tendency to spontaneously suppress negative facial expressions which appears to be related to alexithymia, the ability to accurately pose negative and other facial expressions may be related more to ASD traits and not alexithymia. These possibilities are explored in Chapter 4.

Chapter 4.

Exploring Distinct Correlates of Spontaneous and Voluntary Facial Expressions

4.1. Introduction

Chapter 3 investigated the role of alexithymia in reduced spontaneous production of facial expressions in response to emotional video clips. However, findings from the meta-analysis reported in Chapter 2 revealed that in addition to reduced duration and frequency of facial expressions, individuals with ASD also tend to display facial expressions that are judged to be lower in quality and interpreted with less accuracy—which was not directly assessed in Chapter 3. Thus, one of the goals of Chapter 4 is to assess participants' ability to voluntarily and accurately pose emotional facial expressions for social communication purposes and to determine how performance on this task correlates with ASD traits versus alexithymia. Gordon, Pierce, Bartlett and Tanaka (2014) aptly describe the distinction between spontaneous and voluntary expressions as conceptualized in the present study:

> "…facial expressions are not only the physiological consequences of an internal emotional state (i.e., spontaneous productions), but can also be a consciously controlled social display that are monitored and manipulated in order to meet external (social) demands (i.e., voluntary displays)." (p. 2486)

The novel hypothesis of this study was that spontaneous expressions that resulted from affective arousal and voluntary facial expressions may have distinct correlates. Like Chapter 3, the present study was examined in the context of the alexithymia hypothesis. It was predicted that spontaneous expression will be more strongly and negatively associated with alexithymia than ASD traits (which would replicate findings from Chapter 3), whereas reduced voluntary expression accuracy would be more strongly and negatively related to ASD traits than alexithymia. These predictions arise from several considerations which will be discussed in the following paragraphs.

4.1.1. Correlates of Spontaneous Expression

Several studies reviewed in section 1.5 have demonstrated that alexithymia is negatively associated with facial expression production (McDonald & Prkachin, 1990; Rasting, et al., 2005; Troisi, et al., 1996; Wagner & Lee, 2008), with the majority of these studies (but not all) finding that reduced facial expressions of negative emotions (e.g., anger, fear, sadness, disgust) is more strongly related to high levels of alexithymia than is expression of positive emotions (e.g., joy). Critically, these studies examined alexithymia in relation to *spontaneous* facial expressions during experimental procedures that required adult participants to tell emotional stories about their personal lives, during psychiatric interviews, or in response to images of emotional stimuli. The study in Chapter 3 supported this pattern of results in new populations, finding that alexithymia was negatively correlated with negative facial expression production while watching emotional video clips in two separate samples of children—one comprising children with ASD and one comprising TD children. It was also found that spontaneous facial expression production was not related to a continuous measure of ASD traits in either children with ASD or TD children. Given the finding of continuous relationships between expression production and alexithymia in both ASD and TD children, one goal of the present study is to replicate this pattern of results in a large sample of TD adults.

While it was predicted that reduced spontaneous expression production will be more strongly related to alexithymia than ASD traits, it is possible that ASD traits may still be related to reduced spontaneous expression. The meta-analysis conducted in Chapter 2 reported that on average, the ASD group displayed significantly less spontaneous expression (categorized as “Frequency/Duration” in that study) across a range of naturalistic and laboratory settings compared to non-ASD comparison groups. While it is possible that heightened levels of alexithymia in the ASD group accounted for these group differences in Frequency/Duration, it remains a possibility that there are other characteristics of ASD (unrelated to alexithymia) that contribute to reduced spontaneous expression.

4.1.2. Correlates of Voluntary Expression

In contrast to negative spontaneous expression which appears to be negatively associated with alexithymia (but not associated with ASD traits), it is expected that voluntary expression will be negatively associated with ASD traits rather than alexithymia. This prediction arises from several considerations. First, since voluntary expressions are weakly correlated with internal emotional states (Berry & Pennebaker, 1993), difficulties identifying one's internal emotional states (i.e., alexithymia) may not significantly impact one's ability to voluntarily express emotions when prompted to do so. Indeed, while not reported in their original article, Brewer et al., (2016) found no statistically detectible association between participants' alexithymia and their ability to accurately pose various emotions voluntarily, as measured by the extent to which a separate group of participants could identify their intended emotional expression (R. Brewer, personal communication, May 8, 2017). This finding parallels the findings of McDonald and Prkachin (1990), who examined both spontaneous facial expression production in response to pleasant and unpleasant images and voluntary facial imitation in response to images of actors posing facial expressions in high and low alexithymia groups. They concluded that compared to a low-alexithymia group, the high-alexithymia group's spontaneous facial expressions were significantly less intense, but that no group differences were observed in the intensity of voluntary expression. Thus, while relevant existing empirical data is quite limited, alexithymia appears unrelated to voluntary expression.

Theory and existing evidence point more strongly to the possibility that voluntary expression abilities may be related to ASD traits. Dominant perspectives on ASD have long emphasized deficits in social motivation, mentalizing and social cognition that lead to difficulties understanding the perspectives, thoughts, and emotions of others (Baron-Cohen et al., 1985; Dawson & Fernald, 1987; Harms et al., 2010). Consequently, mentalizing deficits may inhibit one's ability to associate emotional meaning with emotional facial expressions of the self and others (Bird & Viding, 2014), and adversely impact the ability to understand social situations and others' perspectives necessary for appropriately incorporating and integrating nonverbal cues of emotion such as facial expressions into verbal exchanges (Kim et al., 2014). Because voluntary expressions are used for social communication purposes and controlled by brain regions responsible for communication (Purves et al., 2014), the underlying neural mechanisms that give rise to social communication deficits in ASD may directly impact accuracy of voluntary facial expression production.

Moreover, a large body of work summarized in previous review studies have generally found that intentional imitation of bodily, gestural, and facial actions is impaired in individuals with ASD (Edwards, 2014; Williams, Whiten, & Singh, 2004; Williams et al., 2001), which has been explained in terms of difficulties with ‘self-other mapping’—the ability to form and coordinate social representations of self and other via representational processes (Rogers & Pennington, 1991; Williams et al., 2004), or a ‘simulation’ impairment including difficulties imagining others’ perspectives and mapping their body movements with their own behavioral memories (Williams et al., 2001).

Research that has directly examined voluntary facial expression abilities have generally found deficits in posing and imitating deficits in individuals with ASD compared to comparison groups. Several studies have examined the extent to which individuals with ASD accurately pose facial expressions or intentionally imitate facial expression stimuli. In these studies, accuracy was measured via Likert scale coding, FACS coding, or whether observers could interpret the intended emotional meaning. The majority of these studies found that facial expression accuracy is impaired in ASD (Brewer et al., 2016; Loveland et al., 1994; McDonald et al., 1989; Yoshimura et al., 2015), while some failed to find ASD-TD group differences (McIntosh et al., 2006; Stel et al., 2008; Volker, Lopata, Smith, & Thomeer, 2009), and one found *higher* accuracy in ASD (Faso et al., 2014). However, while ASD facial expressions were recognized with greater accuracy in this study by a separate group of raters, they were also rated as significantly more *intense* and significantly more *awkward*, suggesting that the participants’ expressions were not necessarily expressed with greater clarity, but expressed in a more exaggerated fashion to compensate for their awkward expression style (Faso et al., 2014).

The evidence reviewed generates a prediction that voluntary facial expressions will be negatively related to ASD traits, given that ASD traits represent social motivation, mentalizing and social cognitive impairments that may impact the accuracy with which individuals communicate emotions nonverbally via facial expressions. Alexithymia involves reflection on one's own emotional states, which may plausibly impact the ability of individuals to associate internal representations of emotion with external representations of emotion such as facial expressions (Brewer et al., 2016). Thus, voluntary expression accuracy may also be negatively related to alexithymia, although I predict that the relationship with ASD traits will be stronger.

4.1.3. Facial Expressions and Depression

One final consideration is that clinical depression is often accompanied by severe forms of apathy with little emotional reaction to positive or negative events, which contributes to the expression of flat affect (Mayer, Alpert, Stastny, Perlick, & Empfield, 1985; Starkstein, Ingram, Garau, & Mizrahi, 2005; Trémeau et al., 2005). Relatedly, one of the clinical manifestations of depression is "psychomotor retardation" which can cause visual slowing and reductions of a variety of psychomotor functions including speech, gesture and facial expression (Sobin & Sackeim, 1997). This Psychomotor retardation in cases of clinical depression can be traced to abnormalities in the basal ganglia and basal ganglia/thalamo-cortical circuits—brain circuits that are modulated by the extrapyramidal system and exert influence on an array of psychomotor movements such as facial expressions (Sobin & Sackeim, 1997; Ulrich & Harms, 1985). Whether the neural mechanisms contributing to reduced frequency of facial expressions in alexithymia and depression are similar or distinct is not known. This question is further complicated by the view of some theorists who believe that the TAS-20 is merely a measure of psychological distress, based on statistical associations between the TAS-20 and measures of anxiety and depression (Lane et al., 2015; Marchesi et al., 2000, Marchesi, Ossola, Tonna, & De Panfilis, 2014). While negative affect may elevate scores on the TAS-20 to some extent, the stronger theoretical consensus maintains that alexithymia is conceptually distinct from depression, and this elevation may be due to a chronic dysphoria—such that those with severe alexithymia are not able to regulate and resolve negative emotions that result from psychological distress which contributes to generalized feelings of discontentment (Lumley, 2000; Taylor et al., 2016).

In light of these considerations, an additional interest of the present study is the strength and direction of the relationship between alexithymia and depression, as well as whether alexithymia and depression explain unique, or shared variance with spontaneous expression of emotion. In situations in which two or more of the independent variables (alexithymia, depression and ASD traits) are correlated with facial expression variables, statistical methods such as partial correlations or general linear models will be used to assess the independent contributions of each independent variable. Multiple regressions were not used as these analyses require greater statistical power, and because the independent variables are highly intercorrelated which could create potential concerns with multicollinearity.

4.1.4. Present Study

To my knowledge, no study to date has specifically examined distinctions between voluntary facial expressions used for purely social communication purposes compared to spontaneous facial expressions that may be a by-product of affective arousal. A methodology that isolates these processes was necessary to examine the hypothesized distinct correlates of spontaneous and voluntary expression. These hypotheses were tested in a sample of undergraduates from the general student body population by measuring subclinical ASD traits, alexithymia, and depression using standardized questionnaires that are widely used for research purposes in the general population. To assess voluntary expression accuracy, all participants in this study were instructed to "pose" facial expressions in various conditions adapted from Brewer et al.'s (2016) procedure, and their expression accuracy was assessed with FACET using a novel analysis strategy described in Section 4.2.2.4.3. To assess spontaneous facial expression production, a portion of the total sample told emotional stories about their personal lives (adapted from Wagner & Lee, 2008) and a separate portion of the total sample watched emotional video clips similar to the procedures of Chapter 3, although different video stimuli were used that were validated for adults (Rottenberg, Ray & Gross, 2007). The objectives of this study were to test the following hypotheses:

1. *Spontaneous expression* in both the story-telling and video-watching tasks will be more strongly related to alexithymia than ASD traits.
2. *Voluntary expression* will be more strongly related to ASD traits than alexithymia.
3. Based on previous research linking depressive symptoms to flat affect, and high comorbidity between alexithymia and depression, it was also predicted that depression would be associated with spontaneous expression but not voluntary expression.

4.2. Methods

4.2.1. Participants

Participants were originally 114 undergraduates from Simon Fraser University who participated in this study for course credit in Psychology courses, but 26 participants were removed from analysis. Of these 26 participants, one participant reported a diagnosis of a developmental disorder (Asperger Syndrome) and was excluded. The remaining 25 were removed due to problems with their facial expression recordings. The most common reason for exclusion was due to some type of obstruction to the face including glasses, religious adornment or excessive facial hair. Other participants tilted their heads or moved around during the story-telling tasks (see description of task below), both of which significantly impacted the quality of their facial expression readings. Of the final 88 participants (male n = 32, female n = 56), 23 participants (26%) were Psychology majors, and the rest were distributed among majors within the natural sciences, social sciences, and arts. Participant age ranged from 17 to 30 years, (M = 19.59, SD = 2.00).

All 88 participants completed 3 voluntary expression tasks. Of these 88 participants, a subsample (n = 39) completed the story-telling task to assess spontaneous expression production. Due to potential concerns of the story-telling task (see limitations described in section 4.4.1), spontaneous expression was also assessed using a separate video-watching task in a second subsample (n=49). Between these two subsets, there were no significant group differences on age, major or sex.

4.2.2. Measures and Procedures

ASD Traits

ASD traits were measured using the original adult version of the Autism Spectrum Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001). The AQ is a self-report measure scored on a range from 0 to 50, with higher scores indicating higher levels of ASD traits. This measure is a screening tool and is used primarily for research purposes. The AQ assesses social and non-social characteristics of ASD relating to social skills, communication skills, attention to detail, imagination, and tolerance of change. The internal consistency reliability for the AQ was adequate in this sample (α = .77). A full list of the AQ-Adult Version items are located in Appendix D.

Alexithymia

Alexithymia was assessed using the Toronto Alexithymia Scale (TAS-20; Bagby et al.,1994), a self-report measure that assesses adult alexithymia. The TAS-20 consists of 20 items subsumed under 3 subscales, "difficulties identifying feelings," "difficulties describing feelings," and "externally oriented thinking." This measure has been extensively validated and has a stable factor structure representing its 3 subscales (Bagby et al., 1994; Bagby, Taylor, & Parker, 1994; Parker, Taylor & Bagby, 2003). The internal consistency reliability for the TAS-20 was adequate in this sample (α = .82). A full list of the TAS-20's items are located in Appendix D.

Depression

Depression was assessed using the 20-item Zung Self-Rating Depression Scale (ZDS; Zung, 1965). The ZDS was originally intended for assessment within clinical populations but has been extensively validated and used within the general adult population and undergraduate populations (Fountoulakis, Samolis, Kleanthous, Kaprinis, St. Kaprinis, & Bech, 2001; Kitamura, Hirano, Chen, & Hirata, 2004; Sakamoto, Kijima, Tomoda, Kambara, 1998; Shafer, 2006). The ZDS has been used both as a screening tool to assess severity of depressive symptoms in clinical and outpatient participants and has also been used as a continuous measure of depressive symptoms for correlational research (e.g., Gross & John, 2003; Kessler & McRae Jr., 1982). The internal consistency reliability for the ZDS was adequate in this sample (α = .82). A full list of the ZDS's items are located in Appendix D.

Facial Expression Variables

Spontaneous Expression: Story-Telling Task

All facial expression variables were analyzed using the same iMotions facial expression analysis software, 'FACET,' used in Study 2. To measure spontaneous expression, a subset of participants (n = 39) completed Wagner and Lee's (2008) paradigm that instructed participants to describe a "negative life experience" for 90 seconds, followed by describing a "positive life experience" for 90 seconds. Wagner and Lee found that alexithymia was associated with less spontaneous verbal emotional expression and less spontaneous facial expression production in this task as quantified by human raters. Their paradigm was replicated for this study, adapting their methodology by using FACET instead of human raters to assess variability in facial expression production. Facial expressions were analyzed similarly in this task to how they were analyzed in Chapter 3—the variables of interest were how much positive and negative expression were independently expressed both during the positive and negative stories. Participants completed this task while speaking into the webcam of a computer. They knew they were being recorded but were unaware of the true aims of the study. Participants sat approximately 48 inches from the experimenter, and approximately 18 inches in front of the monitor with an external webcam sitting on top of the monitor. The following instructions were read out loud by the experimenter to the participant:

> "For this task, you will be asked to describe positive and negative life events for 90 seconds each. The events can be recent or from a long time ago. Try to choose events that invoke vivid memories and powerful emotions. Please take as much time as you need now to think about what you plan to talk about and let me know when you have chosen your topics." *After participant has confirmed they know their topics*, "Both stories will be videotaped. Please sit still for the entire 90 seconds with your face in clear view of the camera. Try not to move your head or body too much.

> Otherwise, you can speak and act naturally. Speak towards the research assistant as if you are telling them a story. When the 90 seconds are up, the research assistant will say, "time," at which point you can finish your sentence or stop speaking. If you run out of things to say, you can simply stop speaking. Do you have any questions?”

After each story, participants were asked to report how intensely they experienced negative emotion while telling the negative story, and how intensely they experienced positive emotion while telling the positive story on a scale from 1 to 5 (1 being very little, 5 being very much). This procedure was meant to serve as a control variable. For example, if the results reveal a negative relationship between alexithymia and spontaneous expression as predicted, it is important to investigate the possibility that this relationship is explained by higher alexithymic participants experiencing less emotional arousal while telling the stories.

Wagner and Lee (2008) had half of their participants tell their stories alone and half to the experimenter and found no group differences in spontaneous expression. However, in light of other research findings demonstrating that spontaneous displays of emotion are expressed differently depending on the presence or absence of others (Buck, Losow, Murphy, & Costanzo, 1992; Hesse, Banse, & Kappas, 1995; Lee & Wagner, 2002; Wagner & Smith, 1991), in this study, approximately half ($n = 20$) of the participants completed this task with the experimenter in the room while the other half ($n = 19$) completed it without the experimenter present to examine whether social presence of the experimenter will increase emotional expression.

Spontaneous Expression: Video-Watching Task

Even when no researcher is in the room during the story-telling task, the act of telling a story may bias participants’ facial behaviors based on how they normally use facial expressions during social exchanges in their daily lives. Thus, emotional facial expressions exhibited during the story-telling task may not be entirely spontaneous. In addition, the act of speaking requires facial muscle movements that may be erroneously interpreted as emotional expression by FACET. To mitigate these concerns, spontaneous expression was additionally measured using a video-watching paradigm similar to Chapter 3 in a separate subsample of participants ($n = 49$). In this task, participants viewed video clips with emotional content on a computer while their facial expressions were recorded with iMotions' facial expression analysis software. Many of the selected video clips were graphic in nature ranging from scenes of violence, amputations, tense scenes from horror movies, or comedic humor (see Appendix C for descriptions of the full set of video clips) and were previously validated based on their tendency to elicit high self-reported emotional arousal (Rottenberg, et al., 2007). The researcher was in the room with participants, but a large divider was placed between the researcher and participant to give participants a feeling of privacy. Piloting of this task (as well as what was learned from the story-telling task) revealed that participants tended to move around in their seat, place their hands over their face, or look away when they found certain clips difficult to watch—all of which affected FACET's facial expression readings. To get the best possible facial expression readings, the instructions read to participants were modified to mitigate these concerns:

> "For this task, your eye movements will be video-recorded while you watch emotional video clips. To get a good reading on your eye movements it is important that you stay still, in close proximity to the camera and do not move your head around. Also, make sure not to touch your face or cover your eyes. Otherwise, you can let your face act naturally in response to the videos so if you find a clip sad or funny, you don't need to worry about trying not to laugh or trying not to frown – you can let your face move freely. Do you have any questions? Some of these clips are graphic, that you may find difficult to watch. Try as hard as you can to keep watching the whole time without covering your eyes or looking away. That said, if you find a clip too unbearable to watch, let me know and I can advance to the next one. Do you have any questions?"

The ten video clips include 2 clips each of five basic emotions: sadness, anger, fear, disgust, and joy. Piloting failed to identify clips that reliably elicited surprise expressions. Therefore, no such video clips were included in the final stimulus set. The videos ranged from 34 to 261 seconds long. Nine of the clips were presented in randomized order but one of the two funny clips designed to elicit joy—Whose Line Is It Anyway? —was always presented last so that participants would end this task in a good mood. In total, participants spent approximately 29 minutes viewing the video clips. In between each video clip, participants were asked to report how intensely they experienced the target emotion (e.g., disgust or joy) from each video, on a scale from 1 to

5 (1 being very little, 5 being very much). Like the story-telling task, this procedure was meant to serve as a control variable.

Data analysis of these variables (see Results section) found that the two video clips selected to elicit expressions of fear did not reliably elicit fear resulting in floor effects and non-normal distributions with skewness and kurtosis values (2.60 – 7.43) well above what is considered normally distributed and were therefore not analyzed further. Therefore, data from these videos were not included in subsequent correlational analyses. Facial expression data from the 8 remaining videos were composited into two global variables of negative and positive expression. Negative expression was a composite of 6 videos (2 videos each eliciting anger, sadness, and disgust), and positive expression was a composite of the 2 videos that elicited joy. Before being composited, the values were standardized into z-scores so that data from each video would be weighted equally into the composite variable. The decision to composite negative and positive videos was largely driven by a goal of reducing measurement error and maximizing statistical power. It should be emphasized that the way positive and negative expression were calculated for this task was different than how positive and negative expression were calculated in Ch. 3 and in the story-telling tasks. In these tasks, only global measures of positive and negative emotion as estimated directly be FACET were reported. Thus, there was no need for compositing variables in Chapter 3 or for the story-telling task. In the video-watching task in this study, rather than examine global estimates of positive and negative expression simultaneously, only one specific “target” emotion was measured for each video clip. For example, the only facial expression data examined in response to clips chosen to elicit sadness was how much sadness was expressed, and all other facial expression categories were not considered. This strategy was chosen because the clips were validated based on their tendency to elicit self-reported affective arousal on one specific emotion (Rottenberg et al., 2007). Thus, in this example, it was decided that only the expression of sadness would best represent corresponding affective arousal in response to the sad video clip. Indeed, pilot data affirmed that each video clip reliably produced the target emotion as the most frequent facial expression for all clips (except the clips meant to elicit fear).

Voluntary Expression Accuracy

To measure Voluntary Expression Accuracy, Brewer et al.'s (2016) facial expression paradigm was adapted. All participants (n = 88) took part in this task. Participants were instructed to pose expressions of seven basic emotions (anger, fear, sadness, joy, disgust, surprise and contempt) in three prompt conditions (referred to henceforth as Pose, Imitate, and Mirror) resulting in 21 trials, one trial for each emotion X each prompt condition. Each of these conditions are meant to represent mentalizing skillsets that require understanding of others' perspectives to use facial expressions in socially competent ways.

In the Pose condition, they were asked to pose expressions based on a verbal prompt only (e.g., "express anger in such a way that others will understand what emotion you are conveying"). The Pose condition serves as a proxy for how someone poses facial expressions during a social interaction so that others will understand the intended emotional meaning of that expression (e.g., a look of disgust in response to a friend describing a rat infestation in their home).

In the Imitate condition they were prompted to imitate static stimuli of adults posing each of the 7 emotions. Stimuli were selected from the NimStim set (Tottenham et al., 2009) and the Karolinska Directed Emotional Faces (Lundqvist, Flykt, & Öhman, 1998). The Imitate condition is meant to represent how someone may intentionally imitate another's expression for the sake of empathy or to demonstrate understanding of their feelings (e.g., imitating a friend's expression of sadness while they tell a sad story).

In the Mirror condition, the instructions were the same as in the first condition, but this time they viewed a video image of themselves and were told to use their reflection as a 'mirror' to help them form each expression. While the Mirror condition may be less ecologically valid (because normally people do not get opportunities to view their own facial expressions during social interactions), it is meant to represent the expression that best matches participants' internal representation of the visual features of emotional facial expressions (Brewer et al., 2016).

Participants completed this task on the same computer as the spontaneous expression tasks with a webcam sitting on top of the monitor. After participants heard the instructions and indicated they understood the task, participants completed the Pose, Imitate, and Mirror expression conditions in this order. The emotions were randomized within each condition. The Pose condition presented an emotion word (e.g., “fear”), the Imitate condition presented static images of facial expression stimuli (e.g., a human face that looks fearful), and in the Mirror condition, participants viewed an emotion word (e.g., “fear”), along with a live video image of themselves as they attempted to express fear. Participants were instructed to hold facial expressions for approximately 3 seconds after they had generated an expression. This was so that the researcher could ensure that FACET was getting a good reading of the emotion (i.e., detecting the face). If their face was tilted, not facing the camera, moving, or obstructed, the researcher would ask them to try again. In many cases, participants found this exercise quite humorous and spontaneously smiled or laughed when attempting to pose a negative expression. In such cases, they were politely asked to take a moment to compose themselves and try again. There was no time limit for each trial, and all participants managed to successfully complete each posed expression within a reasonable amount of time. In instances when they were instructed to retry a pose for the reasons described above, only their last attempt was analyzed.

When faces are detected by FACET, it generates a probability estimate based on a base 10 logarithmic function for each of the 7 emotional expressions simultaneously and it usually detects more than one emotion at any given time point. A positive value (e.g., ‘2’) represents the probability of 10^2 or 100 times more likely than not that the emotion is present, whereas negative values (e.g., -2) indicate that it is 100 times more likely than not that the emotion is *not* present. Thus, higher values indicate a greater probability that the emotion is present. Because FACET creates a new estimate for each video frame ($1/30^{th}$ of a second), there were approximately 90 frames per posed facial expression. During each 3-second expression, I only analyzed their ‘peak amplitude’ for the intended emotion. In other words, if they were instructed to pose ‘fear’ I analyzed the frame in which FACET estimated the greatest probability that fear was being expressed. Voluntary expression accuracy was coded dichotomously based on whether the target emotion was judged by FACET as being the dominant emotion during the peak amplitude. To illustrate this method, consider a scenario in which participants were instructed to express fear, and FACET detected fear at a 2.13 threshold but detected surprise at a 2.59 threshold. In this case, fear was not the dominant emotion and was counted as a missed trial. For all 21 trials, a ‘1’ was coded for a successful trial, and ‘0’ for a missed trial. In cases where the target emotion and secondary emotion were nearly identical (within .10 threshold values of each other) a score of 0.5 was given.

4.3. Results

4.3.1. Spontaneous Expression of Story-telling Task

Participants were instructed to try to speak for the full 90 seconds for each the positive and negative story, but that they could stop speaking when they ran out of things to say. It was decided a priori that they must speak for at least 30 seconds to be included in analyses. All 39 participants managed to reach this minimum for both stories. The length of the negative stories ranged from 33 to 90 seconds (M = 71.82, SD = 27.48) and the length of the positive stories ranged from 35 to 90 seconds (M = 66.64, SD = 22.00).

Spontaneous expression was calculated as the percentage of time iMotions software separately detected positive and negative expression during each story (positive, negative) at the 1.0 threshold level (10^1 or 10 times more likely than not the expression was present). Data were first analyzed using the 0.5 threshold that was used in prior analyses (Chapter 3). However, the 0.5 threshold resulted in ceiling effects, possibly because the physical act of speaking increased the probability FACET would detect emotions or because participants are more facially expressive while telling stories compared to when watching emotional video clips. Thus, the threshold was raised to 1.0 to capture variance in the increased intensity of these facial expressions. This modification in threshold level resulted in a normal distribution of facial expression detected by FACET. Table 4.1 displays descriptive statistics indicating the extent to which negative and positive expression were detected during the positive and negative stories at the 1.0 threshold level. Results of paired samples *t*-tests revealed that significantly more positive than negative expression was detected by FACET during both the positive story, $t(38) = 7.55$, $p < .001$, and the negative story, $t(38) = 3.44$, $p = .001$.

Table 4.1. Descriptive Statistics for Spontaneous Expression in Story-Telling Task

Story Condition	Facial Expression	Means (SD)	Range
Negative Story	Negative	24.42 (16.63)	0-65%
	Positive	35.80 (22.71)	0-94%
Positive Story	Negative	19.04 (15.37)	0-59%
	Positive	37.11 (18.33)	2-95%

All distributions of facial expression variables had skewness and kurtosis values within ±1.96, which is within the range of 'normally distributed' for small samples (Field, 2013). There were no group differences in amount of positive or negative expression based on whether the researcher was in the room (*p*s > .18), and therefore this variable was not analyzed further. Table 4.2 displays intercorrelations among negative expression, positive expression, the Toronto Alexithymia Scale (TAS-20), the Autism Spectrum Quotient (AQ) and the Zung Self-Rating Depression Scale (ZDS). All but the ZDS was normally distributed and in the normal skewness and kurtosis range (ZDS kurtosis = 3.24; Skewness = 1.22). Visual inspection revealed that this kurtosis was driven by one outlier who scored 73 whereas all other scores fell with the range of 24 – 53. Removal of this outlier resulted in a kurtosis value that fell within the normal range. However, removal did not result in any changes in statistical significance in the observed correlation coefficients and therefore it was decided to leave this outlier in. Data exploration revealed no other concerns of outliers. TAS-20 scores range from 25 to 85 (M = 47.43, SD = 11.88), AQ scores ranged from 5 to 35 (M = 18.56, SD = 6.07), and ZDS scores ranged from 24 to 73 (M = 41.05, SD = 8.98). Self-reported emotional arousal ranged from 1-5 for SR Positive during the positive story (M = 2.95 SD = 0.89) and ranged from 2-5 for SR Negative during the negative story (M = 3.00, SD = 0.83).

Table 4.2 displays intercorrelations among the questionnaire and facial expression variables during the story-telling task. A key interest of Table 4.2 is whether negative expression is more strongly related to alexithymia than ASD traits. Because negative expression was significantly correlated with both the TAS-20 (r = -.591, p < .001), and the AQ (r = -.393, p = .013), and because the AQ and TAS-20 were moderately correlated in this subsample (r = .432, p = .006) follow-up analyses were conducted to see if either the TAS-20 or AQ was primarily driving these associations. After partialling out the effect of AQ, the relationship between TAS-20 and negative expression remained significant (partial r = -.508, p = .001). However, after partialling out the effect of TAS-20, the relationship between the AQ and negative expression dropped below the level of statistical significance (partial r = -.189, p = .255). Further, as discussed in the introduction, it was of interest to explore whether ZDS mediated the association between TAS-20 and negative expressions. After partialling out the effect of ZDS, the relationship between TAS-20 and negative expression remains statistically significant, (partial r = -.371, p = .022). In addition, negative expression during the positive story was significantly correlated with the TAS-20 (r = -.411, p = .009), but not the AQ (r = -.275, p = .090). However, after partialling out the effect of ZDS in the association between TAS-20 and negative expression during the positive story, the relationship dropped below the level of statistical significance, (partial r = -.265, p = .108). This pattern of results supports the hypothesis that negative expression is more strongly related to alexithymia than ASD traits. Further, depression mediates some, but not all of the variance in the association between alexithymia and negative expression during the negative story, but fully mediates the relationship between alexithymia and negative expression during the positive story. Both the AQ and TAS-20, but not the ZDS, were significantly associated with positive expression during the positive story. These associations are likely due to shared variance between the AQ and TAS-20, as correlations for TAS-20 (partial r = .302, p = .069) and AQ (partial r = -.197, p = .243) dropped below statistical significance after the effect of the other was partialled out. Neither the AQ, ZDS, nor TAS-20 were correlated with positive expression during the negative story.

The only significant correlation between either of the control variables capturing self-reported emotional arousal (SR Negative and SR Positive) and other variables was a negative relationship between the ZDS and SR Negative, consistent with the view that greater depression is associated with reduced self-reported emotional responsiveness (i.e., apathy). However, neither SR Negative nor SR Positive were associated with any of the spontaneous expression variables. This finding suggests that self-reported emotional arousal is not associated with self-reported alexithymia or ASD traits.

Table 4.2. Intercorrelations Among Spontaneous Expression in Story-Telling Task and Questionnaires

	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Negative expression (negative story)		.763**	.482**	.487**	-.591**	-.393*	-.525**	-.066	.121
2. Negative expression (positive story)			.609**	.619**	-.411**	-.275	-.334*	-.112	.042
3. Positive expression (negative story)				682**	-.192	-.114	-.152	-.230	-.073
4. Positive expression (positive story)					-.329	-.318*	-.191	-.092	-.069
5. TAS-20				.		.432**	.692**	-.158	-.280
6. AQ							.419**	-.108	-.252
7. ZDS								-.125	-.363*
8. SR Positive									.395*
9. SR Negative									

Note. **Correlation is significant at the .01 alpha level (2-tailed). *Correlation is significant at the .05 alpha level (2-tailed). TAS-20 = Toronto Alexithymia Scale, AQ = Autism Spectrum Quotient, ZDS = Zung Self-Rating Depression Scale, SR Negative = Self-reported experience of negative emotion during negative story, SR Positive – Self-reported experience of positive emotion during positive story. n = 39

4.3.2. Spontaneous Expression of Video-Watching Task

Eight of the 10 video stimuli (excluding the videos designed to elicit fear) reliably elicited the intended facial expression based on their success in producing normal distributions of facial expressions (see Appendix C for descriptions of the video stimuli). Distributions of facial expression variables for all eight videos fell within the normal skewness and kurtosis range of ±1.96. All the questionnaire variables fell within the normal skewness and kurtosis range although SR Negative and SR Positive had kurtosis values that exceeded this range. SR Negative had a kurtosis value of 3.81. Visual inspection revealed that this kurtosis was driven by one outlier. However, removal of this outlier did not result in any changes in statistical significance in the observed correlation coefficients; therefore, it was decided to leave this participant in the analyses. SR Positive also had a problematic skewness value of 2.58. Two outliers were identified and removed to normalize the distribution. Again, removal did not result in any changes in statistical significance in the observed correlation coefficients and it was decided to leave the outliers in the analysis. The mean self-reported emotional arousal ranged from 1-5 for SR Positive in response to the video clips designed to elicit positive emotion (M = 4.04 SD = 0.90) and ranged from 1.33-4.83 for SR Negative in response to the video clips designed to elicit negative emotion (M = 3.84, SD = 0.65).

Spontaneous expression was quantified as the percentage of time the target emotions were detected during each video clip at the 0.5 threshold level ($10^{0.5}$ or 3.16 times more likely than not that the expression was present). Again, this threshold value was chosen based on which threshold value resulted in the most normally distributed data to avoid ceiling or floor effects that could attenuate observed correlations. Means and standard deviations for the amount of time each target emotion was detected are reported in Table 4.3, along with titles of the movie clips. Self-reported emotional arousal was recorded for each video, but each judgment was collapsed in the same way as the facial expression variables for subsequent correlational analyses such that SR Negative was a composite of self-reported arousal for the six videos that elicited negative emotions and SR Positive was a composite of the two videos that elicited joy.

Table 4.3. Means and Standard Deviations of Percentage of Time Spontaneous Expression was Detected During Video-Watching Task

Video	Emotion	Mean (SD)
Pink Flamingos	Disgust	46.55 (24.18)
Toe Amputation	Disgust	46.38 (23.53)
Shawshank Redemption	Sadness	35.67 (23.39)
The Champ	Sadness	44.31 (28.41)
Silence of the Lambs*	Fear	10.45 (17.61)
The Shining*	Fear	8.69 (13.25)
My Bodyguard	Anger	43.94 (23.59)
Cry Freedom	Anger	45.30 (24.89)

Video	Emotion	Mean (SD)
When Harry Met Sally	Joy	44.52 (25.79)
Whose Line Is It Anyway	Joy	63.83 (17.00)

Note. *These videos were removed from subsequent analyses due to floor effects.

Table 4.4 displays intercorrelations among the questionnaire and facial expression variables during the video-watching task. The pattern of correlations found in this analysis differed from those on the story-retelling task; however, in general, the results are consistent with predictions. Results show that the only significant correlate of negative expression was the TAS-20, (r = -.472, p = .001) whereas the AQ and ZDS were not significantly related to negative expression, suggesting alexithymia is associated with less expression of negative affect in response to videos designed to elicit disgust, sadness or anger

Neither the TAS-20 nor AQ were significantly correlated with positive expression. The only significant correlate of positive expression was the ZDS (r = -.385, p = .007), suggesting depression is associated with less positive displays of affect in response to humorous video clips. This finding is consistent with the notion that depression is associated with apathy which is characterized in part by less positive emotional reaction to positive events. The lack of association between positive affect and alexithymia is consistent with findings from the video-watching task in Chapter 3, where it was found that alexithymia was significantly and negatively associated with negative expression, but not significantly associated with positive expression, in response to the emotional video clips in children with and without ASD. Neither SR Negative nor SR Positive was associated with any of the questionnaire or facial expression variables, suggesting that self-reported emotional arousal variables are not accounting for the significant relationships between the questionnaire variables and the facial expression variables.

Table 4.4. Intercorrelations Among Spontaneous Expression in Video-Watching Task and Questionnaires

	1.	2.	3.	4.	5.	6.	7.
1. Negative Expression		.305*	-.472**	-.148	-.215	.014	-.101
2. Positive Expression			-.258	-.049	-.385**	.069	-.125
3. TAS-20				.284*	.420**	.038	.246
4. AQ					.296*	.114	.024
5. ZDS						-.036	.055
6. SR Positive							.255
7. SR Negative							

Note. **Correlation is significant at the .01 alpha level (2-tailed). *Correlation is significant at the .05 alpha level (2-tailed). TAS-20 = Toronto Alexithymia Scale. AQ = Autism Spectrum Quotient. ZDS = Zung Self-Rating Depression Scale. SR Negative = Self-reported experience of negative emotion during negative story, SR Positive – Self-reported experience of positive emotion during positive story. n = 49

4.3.3. Voluntary Expression

The means and standard deviations of Voluntary Expression Accuracy for each emotion in each condition are reported in Table 4.5. Data from all three conditions were normally distributed with skewness and kurtosis values within the normal range of ±1.96, with no concerns of floor or ceiling effects. These means are reported within a possible range of 0 to 1 representing the proportion of trials that were expressed correctly in each condition (0 representing no correct trials and 1 representing all correct trials). The row titled ‘Average’ is the mean proportion of correct trials averaged across all emotion categories for each condition. The expression ‘joy’ was left out of the averages for all conditions due to ceiling effects. The averages at the bottom of each row in Table 4.5 represent the variables used in subsequent correlational analyses (see Table 4.6).

To determine if participants’ scores differed according to condition, a within subjects analysis of variance (ANOVA) was ran. This analysis confirmed that the three voluntary expression conditions differed at a statistically significant level, $F(2,174) = 24.902$, $p < .001$. Post hoc tests using the Bonferroni correction revealed that Pose differed at a statistically significant level from both Imitate, (Mean difference = 0.705, $p < .001$), and Mirror (Mean difference = 1.011, $p < .001$). ‘Imitate’ and ‘Mirror’ did not differ from each other at a statistically significant level (Mean difference = 0.307, p = .154). These results suggest that the Pose task was more difficult than the Imitate and Mirror tasks, which is not surprising given that participants had relatively more information in both the Imitate and Mirror tasks to aid their performance. For the Imitate and Mirror tasks, participants were aided by external images of themselves or others expressing the target emotion, whereas for the Pose task, participants viewed only a word (e.g., "anger") before expressing the target emotion.

Table 4.5. Means and Standard Deviations of Voluntary Expression Accuracy.

Emotion Type		**Mean (SD)**	
	Pose	**Imitate**	**Mirror**
Anger	0.55 (0.45)	0.47 (0.43)	0.62 (0.45)
Fear	0.23 (0.36)	0.18 (0.34)	0.35 (0.40)
Sadness	0.35 (0.42)	0.42 (0.43)	0.53 (0.43)
*Joy	1.00 (0.00)	1.00 (0.00)	0.99 (0.05)
Disgust	0.48 (0.45)	0.65 (0.41)	0.52 (0.46)
Surprise	0.32 (0.43)	0.69 (0.44)	0.75 (0.41)
Contempt	0.07 (0.23)	0.28 (0.39)	0.23 (0.36)
Average	0.33 (0.18)	0.45 (0.22)	0.50 (0.21))

**Note.* Average represents the mean proportion of accuracy across all emotions for each condition excluding joy. Joy was left out of the composites due to ceiling effects. The averages represent the variables, 'Pose,' 'Imitate,' and 'Mirror' used for correlational analyses reported in Table 4.6.

Intercorrelations were analyzed among the three Voluntary Expression Accuracy variables, and the questionnaire variables reported in Table 4.6. It was predicted that the AQ would be more strongly associated with Voluntary Expression Accuracy than the TAS-20 or ZDS. When analyzing each condition separately, a somewhat inconsistent pattern of results emerged. As Table 4.6 shows, Pose was significantly correlated with the TAS-20 (r = -.327, p = .002), the AQ (r = -.266, p = .012 and the ZDS (r = -313, p = .003). The only significant correlate of Mirror was the AQ (r = -.259, p = .015), and there were no significant correlates of Imitate.

Because all three of the questionnaire variables (TAS-20, AQ and ZDS) were significantly correlated with performance on the Pose condition, a general linear model was ran with each of the questionnaire variables entered simultaneously as predictors in the model, and 'Pose' entered as the dependent variable. The corrected model was statistically significant, $F(3,83) = 4.754$, $p = .004$, $R^2 = .147$, Adjusted $R^2 = .117$. None of the predictors independently emerged as significant predictors, but the Type III sums of squares (SS) indicate the relative independent contributions of each variable; for TAS-20, $F(1,86) = 2.132$, SS = 2.075, $p = .148$; for AQ, $F(1,86) = 1.607$, SS = 1.564, $p = .209$, and for ZDS = $F(1,86) = 1.833$, SS = 1.833, $p = .174$. This pattern of results suggests that each one of the predictor variables contributed relatively equally to the model and that no one of these variables is driving the variance in performance on the Pose task. Instead, the shared variance among ASD traits, alexithymia and depression is accounting for variance on the Pose task.

Table 4.6. Intercorrelations Among Voluntary Expression Accuracy and Questionnaires

	1.	2.	3.	4.	5.	6.
1. Pose		.390**	.338**	-.327**	-.266**	-.313**
2. Imitate			.358**	-.027	.109	-.011
3. Mirror				-.063	-.259*	.000
4. TAS-20					-.344**	.536**
5. AQ						.346**
6. ZDS						

Note. **Correlation is significant at the .01 alpha level (2-tailed). *Correlation is significant at the .05 alpha level (2-tailed). Total = Sum of Pose, Imitate and Mirror. TAS-20 = Toronto Alexithymia Scale. AQ = Autism Spectrum Quotient. ZDS = Zung Self-Rating Depression Scale. n = 88

4.4. Discussion

The purpose of this study was to examine whether the correlates of emotional facial expression production abilities differ based on whether they are *spontaneously* produced (i.e., involuntary facial expressions resultant from affective arousal), or *voluntarily* produced (i.e., consciously controlled displays used for social communication purposes). Spontaneous facial expression production was examined in two different ways, in two separate subsamples. For these spontaneous tasks, it was predicted that alexithymia would be more strongly related to spontaneous expression than ASD traits, while considering the potential role of depression in these associations. In the first task, participants' facial expressions were recorded while they told stories about positive and negative life experiences. In this task, alexithymia was moderately and significantly correlated with negative facial expression production both during telling of the negative and positive stories. During the negative story, the association between alexithymia and negative facial expression remained significant after accounting for shared variance in negative expression attributable to the ASD traits and depression. However, the association between alexithymia and negative facial expression during the positive story dropped below the level of significance after partialling out the effects of depression. In contrast, the relationship between ASD traits and negative expression during the negative story was not independent of the association between alexithymia and negative expression.

There were no significant correlates of positive expression during the negative story. However, both alexithymia and ASD traits (but not depression) were significantly associated with less positive expression during the positive story. Partialling out the effects of ASD traits on alexithymia—or partialling out the effects of alexithymia on ASD traits—both resulted in nonsignificant partial correlations. This finding suggests that neither of these variables independently accounts for variance in positive expression during the positive story, and that only the shared variance between alexithymia and ASD traits significantly accounts for variance in positive expression.

A somewhat different pattern of results was observed for the other task designed to elicit spontaneous expressions—this time in response to video clips that were chosen to elicit positive and negative emotional reactions. In this task, the only significant correlate of negative expression was alexithymia (and not depression or ASD traits). However, reduced spontaneous positive expression was associated only with higher levels of depression (and not alexithymia or ASD traits). For this task, neither negative nor positive expression was significantly correlated with ASD traits. The pattern of results from both spontaneous facial expression tasks provides partial support for predictions—that when facial expressions are spontaneously produced in response to affective arousal, reduced expression is primarily associated with adverse emotion processing conditions—alexithymia and depression. It is worth considering what depression and negative expression were significantly correlated for the story-telling task, but this association was not observed for negative expression during the video-watching task. One possibility is that story-telling is more personal to the individual and thus contributes to stronger negative emotional reactions, whereas individuals may experience no personal connection (and therefore less emotional arousal) to the characters in the videos and therefore may not invoke feelings of depression in individuals with higher depressive traits. Importantly, across both the story-telling and video-watching tasks, spontaneous expression was more strongly related to alexithymia than it was to ASD traits, providing additional support for the 'alexithymia hypothesis' (Bird & Cook, 2013).

In contrast to the hypotheses about spontaneous expression production, it was predicted that ASD traits (and not alexithymia or depression) would drive variance in voluntary expression accuracy. Minimal support was provided for this prediction, as only one of three voluntary expression conditions, Mirror, showed a pattern of results such that ASD traits but not alexithymia or depression were significantly correlated with voluntary expression accuracy. For the Pose condition, all independent variables (ASD traits, alexithymia and depression) were significantly associated with performance in this task. Results of a general linear model confirmed that with all predictors entered into the model, they accounted for a small but statistically significant proportion of variance in performance on this task. However, no one variable in the model emerged as independently significant when accounting for the variance of the other predictors in the model, suggesting that the shared variance between ASD traits, alexithymia and depression are accounting for variance in voluntary expression accuracy in this condition. Finally, there were no significant correlates of performance in the 'Imitate' condition. It is possible that these voluntary tasks lacked ecological validity and do not necessarily tap into competencies related to how participants would use voluntary expressions to regulate social interactions in real-world settings. These tasks were untimed and examined in typically developing adults who—even if they had some ASD traits—had plenty of time to reasonably draw upon compensatory strategies to form expressions. Still, the mean proportion of correct trials across (ranging from 0.33 to 0.50 collapsed across emotion category for each condition) suggests the tasks were not too easy. In fact, these tasks may have been slightly too difficult. In particular, the low degree of accuracy on the Pose task in combination with somewhat restricted variance may have attenuated the magnitude of correlations.

Given that there was a different pattern of correlations associated with each of the three voluntary expression conditions, it is possible that each of these conditions represent somewhat distinct constructs. Indeed, results of the within-subjects ANOVA revealed that the Pose task was significantly more difficult for participants than the Imitate or Mirror tasks. It is important to consider this finding in light of the result that alexithymia was significantly correlated with the Pose task but not Imitate or Mirror tasks. To successfully complete the Pose task, participants had no external facial expression to view that would aid their performance on this task. Thus, participants had to draw from *internal* representations of emotions to generate a facial expression in this task. Given that alexithymia is characterized by difficulties identifying and differentiating emotions in the self, alexithymia may have particularly impacted performance on the Pose task. In contrast, having an external stimulus to view (either of themselves or others) in the Imitate and Mirror tasks, may have served as enough of a compensatory mechanism to mask the potential mitigating effects of alexithymia on performance in these conditions.

Findings from this study provide some support for the initial predictions, that spontaneous and voluntary expression production may have somewhat distinct correlates. Consistent with the findings from Chapter 3, alexithymia was negatively associated with spontaneous negative facial expression production both during the story-telling and video-watching tasks, even after partialling out the effect of depression and ASD traits in most cases. In addition to alexithymia, another variable associated with reduced spontaneous positive expression (when viewing humorous video clips) was depression. This finding is consistent with a symptom of depression known as *apathy*, which is often accompanied by unchanging or flat affect, and lack of emotional response to positive or negative events (Starkstein et al., 2005; Starkstein, Petracca, Chemerinski, & Kremer, 2001), as well as abnormalities in brain regions responsible for psychomotor functioning that may impact facial expression production (Jones & Pansa, 1979; Sobin & Sackeim, 1997). Moreover, in the present study, alexithymia and depression were moderately correlated across the whole sample (r = .536), suggesting these constructs overlap considerably and that their respective associations with reduced spontaneous facial expression production may be similar in nature.

A different possible explanation for the relationships between alexithymia and depression on reduced spontaneous expression is that alexithymia and depression were negatively associated with emotional *arousal* during the video-watching and story-telling tasks. This possibility was controlled for by asking participants to report how intensely they experienced negative and positive emotions after each story they told and after each video they watched. These control variables did not correlate with facial expression production in either of the tasks, suggesting that the negative relationships between spontaneous expression and both alexithymia and depression is not explained by individuals' self-reported affective arousal during the tasks. Future research would benefit from using physiological measures such as heart rate or skin conductance methods as a more valid control measures.

4.4.1. Limitations

It is difficult to ethically elicit emotions for research purposes in laboratory settings (Rottenberg et al., 2007). While the methods used in this study were effective in eliciting emotional facial expressions, they lacked ecological validity. Telling personal stories to a researcher in a laboratory while being videotaped may not be an accurate representation of how individuals behave in naturalistic settings—for example, when telling a friend or family member personal stories. In addition, the act of speaking during the story-telling task may have biased the facial expression estimates such that FACET erroneously interpreted facial movements associated with speaking as emotional expressions. Moreover, the ways in which people spontaneously express emotions in response to emotion-eliciting video clips may not be indicative of how such individuals would respond to environmental stimuli in naturalistic settings. Nevertheless, both paradigms were effective in eliciting emotional expressions as evidenced by the wide variance of distributions in facial expression variables, and because individual differences in facial expression production correlated with ASD traits, depression and alexithymia, consistent with hypotheses and theory.

The sample in this study was predominantly female representing a very different sex distribution than what was detailed in Chapter 3 and is quite different than the sex ratio in the ASD population. An untested possibility is that some of the unsupported hypotheses of this study (especially in regard to correlations involving ASD traits), may be confounded by the high proportion of females in this study. Although this may be an interesting question for future research, in the present study, there was no theoretical grounds for hypothesizing why correlations between alexithymia, ASD traits, depression and facial expression variables would be moderated by sex, and therefore was not an interest of this investigation.

A number of methodological challenges were experienced during the data collection analysis phases of this study contributing to a significant amount of lost data. The facial expression analysis software proved to be highly sensitive to subtle tilting and movements of the head, as well as obstructions to the head/face region. Moreover, videos from the video-watching task selected to elicit fear were not included in composite variables for correlational analyses due to a failure to elicit fearful expressions, and voluntary expressions of joy were not included in correlational analyses due to ceiling effects. The high degree of data loss, and decisions to collapse various variables were all driven by a goal of reducing measurement error and maximizing statistical power. The methodological problems encountered in this study call for increased validation work of facial expression analysis software, and the need for the development of more rigorous methodological guidelines and procedures for conducting psychological research with such software.

Moreover, data from the Imitate condition failed to correlate with alexithymia, ASD traits or depression. The researchers observed that participants had specific difficulties with this task, often commenting that the expressions of the photographs they were meant to mimic appeared odd, and that they would not express emotions like that personally. As a result, the imitated expressions often appeared bizarre, and it is possible that this variable did not fairly reflect participants' Voluntary Expression Accuracy. As these stimuli were obtained from stimuli sets of untrained actors "posing" various expressions, future research on imitation accuracy may benefit from using more ecologically valid facial expression stimuli. Further, an important limitation is that participants only completed one trial for each emotion in each condition. It is possible that this attenuated the magnitude of correlation coefficients due to low reliability, and future research should conduct multiple trials to decrease measurement error and increase reliability.

A final important limitation to emphasize is that the research questions investigated in this study were examined using simple correlational analyses, and therefore causation cannot be determined. In addition, there was a high degree of correlation among the independent variables (alexithymia, depression, and ASD traits) making it difficult to interpret some of the results. These interpretations were further hampered by low statistical power stemming from small sample sizes. Longitudinal research designs and structural equation modeling techniques may be useful for demonstrating causal inferences in future research. In addition, conducting similar studies with separate clinical samples including those with clinical depression, ASD, or high rates of alexithymia may help to elucidate potential differences in facial expression profiles among different clinical populations.

Chapter 5.

General Discussion

The purpose of this dissertation was to determine in what ways, and in what contexts, facial expressions are atypical in the ASD population in relation to typically developing (TD) or non-ASD clinical comparisons (Chapter 2), to investigate the relationship between alexithymia and spontaneous facial expression production in children with and without ASD (Chapter 3), and to explore how alexithymia, ASD traits and depression may be related to spontaneous and voluntary facial expressions in the general population (Chapter 4). These studies helped provide nuance to our empirical understanding of how, and why, individuals with ASD communicate emotions nonverbally via facial expressions differently than in typical development.

5.1. Summary of Findings

The meta-analysis reported in Chapter 2 found that relative to TD individuals, individuals with ASD display facial expressions less frequently and for less duration, and they are less likely than TD and non-ASD clinical groups to share facial expressions with others in naturalistic settings or to automatically mimic the expressions of real faces or face stimuli. Their facial expressions are also judged to be more awkward or unusual in appearance and are expressed less accurately—sometimes making it difficult for observers to identify which emotion is being expressed. However, across studies, participants with ASD do not express emotions less intensely, nor is their reaction time of expression onset slower in response to odors, startling sensations, or in response to face stimuli in mimicry studies.

Consistent with developmental theories of ASD, these findings may be explained by less social understanding of when and how to use facial expressions for social communication purposes, less social motivation, mentalizing impairments, and possibly an impaired Mirror Neuron System (MNS). That said, the findings of this meta-analysis do not provide grounds to identify which theories are especially supported by the findings. For example, impairment in the MNS (facilitation of ‘seeing’ and ‘doing’ actions) may seem to most directly impact imitation abilities; but from a developmental perspective, MNS impairment in early childhood could trigger a developmental trajectory that could account for a large number of social-emotional differences that could reasonably impact all facial expression production outcome variables summarized in Chapter 2. Thus, rather than speculate which theories are supported by the data, it is more useful to discuss how these theories may be extended in consideration of other key findings from this dissertation.

The results of Chapters 3 and 4 suggest that a critical explanation of facial expression differences observed in ASD may stem from alexithymia, which is a condition not traditionally considered in dominant developmental theories of ASD. In consideration of findings from Chapter 2 that across studies, participants with ASD express emotions less frequently and for less duration and that they do so with less accuracy, findings from Chapters 3 and 4 indicate that heightened levels of alexithymia in the ASD population (Hill et al., 2004) may play a role in these ASD deficits. This possibility is speculative, however, as none of the studies synthesized in Chapter 2 reported alexithymia scores of their ASD or comparison samples.

Additional moderator analyses revealed that age and intellectual functioning moderated the strength of the ASD-comparison group differences such that group differences became smaller as age and intellectual functioning of the ASD group increased. These findings may suggest that older and more intellectually capable individuals with ASD are more likely to have learned strategies for displaying facial expressions that are in line with typical developmental norms. Similarly, it was found that the ASD-comparison group differences became smaller when groups were matched on age *and* intellectual functioning, compared to when matched only on age *or* intellectual functioning, providing evidence that differences in age and intellectual functioning between groups may exaggerate differences in facial expression production. The average effect on facial expression differences across studies was ($g = -.730$, $p < .001$, $df = 9$) for individuals with ASD with intellectual disabilities, with minimal group differences observed for groups in the normal intellectual functioning range ($g = -.198$, $p < .001$, $df =$

21). It is striking that intellectual functioning plays such a major role in facial expression production—a skillset that seemingly has little theoretical overlap with intellectual functioning. This finding is an important reminder that the heightened prevalence of intellectual impairment in the ASD population plays a major role in social skill development and social behavior in this population.

Finally, ASD-comparison group differences were larger when facial expressions were elicited covertly (i.e., in paradigms in where participants were not prompted to display facial expressions) compared to when facial expressions were elicited explicitly (i.e., in paradigms wherein participants were instructed to pose or imitate facial expressions), suggesting individuals with ASD may be equipped to 'fake' social competencies or compensate for social difficulties in the confines of a laboratory setting, but that their social differences may become more apparent in naturalistic or research settings in which their natural social behavior is being examined. These findings parallel observations that "manifestations of core social deficits in autism are more pronounced in everyday settings than in explicit experimental tasks" (Klin et al., 2002, p. 809), and call for the need for ASD researchers to develop methods for examining social behavior in settings that closely replicate naturalistic social settings without sacrificing experimental control.

Chapter 2 represents the first systematic and exhaustive review of the rather limited research on facial expression production in ASD, demonstrating which aspects of facial expression production are impaired or intact in ASD. Moreover, given the variability in methodologies used to explore facial expression production in this literature base, the moderator analyses helped to explain the heterogeneous pattern of empirical results reported in the studies reviewed in Chapter 2. In summary, this study found that participants with ASD express emotions less frequently, with lower quality and accuracy, and are particularly impaired in their ability to reciprocate emotions via mimicry or when using facial expressions in socially congruous ways. These ASD differences were maximized in individuals that are younger, less intelligent, and in contexts in which facial expressions were examined in more naturalistic settings. As this study was largely designed to characterize the extent of ASD-comparison group differences on facial expression abilities, subsequent studies reported in Chapters 3 and 4 aimed to identify variables that may explain variance in atypical facial expression production.

While Chapter 2 was useful for characterizing the nature of facial expression production differences in the ASD population, the purposes of Chapters 3 and 4 were to examine how alexithymia, ASD traits, and depression may be related to facial expression abilities in children with ASD and in TD adults. Consistent with Bird and Cook's (2013) alexithymia hypothesis, Chapter 3 found that alexithymia—and not severity of parent-reported ASD traits or diagnosis—was negatively associated with spontaneous production of negative facial expressions in response to emotionally arousing stimuli. A similar pattern of results was found in Chapter 4. In general, alexithymia and depression were negatively associated with spontaneous production of facial expression during tasks that required TD undergraduates to watch emotional video clips or tell emotional stories about their personal lives.

In a separate set of tasks in which participants were instructed to voluntarily pose emotional facial expressions, a murkier pattern of results emerged. When participants were instructed to pose emotional facial expressions based on a verbal prompt only, performance on this task was correlated relatively equally with each alexithymia, depression and ASD traits, and follow-up tests from a general linear model revealed that only the shared variance among these variables predicted performance on this task. Surprisingly, there were no significant correlates of voluntary expression accuracy for the Imitate task that required participants to imitate static images of actors posing various emotions. However, ASD traits were the only significant correlate of voluntary expression accuracy on the Mirror condition—which required participants to pose expressions with the help of their own video images as a mirror—consistent with predictions. In all, results suggest that reduced spontaneous expression and reduced voluntary expression accuracy may have somewhat distinct underlying mechanisms, although the correlational designs of these studies do not allow for causal inferences.

While the combination of results from Chapters 3 and 4 suggest spontaneous and voluntary facial expression production may have somewhat distinct correlates, they are unlikely to be completely distinct. ASD traits and alexithymia were moderately correlated in Chapter 4, so it is not surprising that both variables were somewhat associated with facial expression production variables in these studies. Indeed, Chapter 4 revealed that alexithymia was significantly correlated with lower voluntary expression accuracy in one of the three posing conditions (Pose), and ASD traits had small to moderate negative correlations with spontaneous expression in Chapters 3 and 4, but to a lesser extent than alexithymia. However, the general pattern of results provides some support for initial predictions and invites future research with different designs to confirm these links. For example, several studies that examined the 'alexithymia hypothesis' reviewed earlier, use comparative designs that match ASD and TD groups on levels of alexithymia, in addition to age, intelligence and sex. Theoretically, any social-emotional differences in ASD that are accounted for by heightened levels of alexithymia in this population should result in null group differences when groups are matched on alexithymia. Thus, to confirm the pattern of results predicted in Chapter 4, a design that matches ASD and TD groups on alexithymia and measures facial expression production in spontaneous and voluntary tasks, should result in null group differences in amount of spontaneous expression production, but should result in lower scores on voluntary expression accuracy in the ASD group.

5.2. Theoretical Explanations for Findings from Chapters 3 and 4

Here, the findings from Chapters 3 and 4 will be considered in the context of dominant ASD theories reviewed earlier. As will be described, these theories are useful in explaining why ASD traits are negatively correlated with voluntary expression accuracy. However, these theories do not account for why alexithymia (and to lesser extent, depression) is associated with less spontaneous expression in individuals with ASD and in the general population. Less traditional theoretical explanations will be explored to help explain this association.

5.2.1. ASD Traits in Relation to Facial Expression Production

In Chapter 4, zero-order correlations revealed that ASD traits were significantly and negatively correlated with two of the three voluntary expression accuracy variables: Pose, which required participants to pose expressions based on a verbal prompt, and Mirror, which required participants to use a video image of themselves as a mirror to help them form each expression, but not Imitate which required participants to imitate static stimuli of adults posing emotional expressions. However, the association between ASD traits and performance on the Pose condition dropped below statistical significance when accounting for the effects of depression and alexithymia. Thus, the only clear support for my original hypothesis was found for the Mirror task, such that ASD traits, but not alexithymia or depression, were associated with performance on this task. This finding may be interpreted in light of mentalizing impairments associated with ASD traits. The social motivation theory and mentalizing frameworks suggests that individuals with ASD have deficient cognitive mechanisms necessary for understanding others' mental states and emotions (Baron-Cohen, 2005; Chevallier et al., 2012). Because individuals with ASD have relative difficulty inferring the emotional meaning of others' facial expressions (Harms et al., 2010), individuals with ASD may have less accurate cognitive representations of how to display emotional information themselves via facial expressions when prompted to do so. While participants with ASD were not utilized in Chapter 4, the finding that ASD traits are negatively associated with performance in the Mirror condition supports predictions that emerge from social motivation and mentalizing frameworks. This finding is also consistent with findings from Chapter 2 that across studies, individuals with ASD voluntarily pose and imitate facial expressions with less accuracy compared to non-ASD comparison groups. Like the Pose condition, the Mirror condition still required participants to generate facial expressions based on their own cognitive representations of how to represent emotional information via facial expressions, so even though they had the aid of their own video image as a mirror in this condition, impaired understanding of the visual appearance of emotions would still be a detriment to performance in this task.

Surprisingly, ASD traits were not significantly associated with performance in the Imitate condition. A key difference of this task from the Mirror condition is that the Imitate condition required imitation of static stimuli of adults posing facial expressions. Thus, the Imitate condition may have especially relied on the MNS which facilitates connections between *observing* an action and *performing* that action (Williams et al., 2001). Given that ASD is associated with MNS impairment and theorized to be a mechanism contributing to social communication deficits in ASD (Williams et al., 2001; Dapretto et al, 2006), and because the studies synthesized in Chapter 2 found ASD deficits in voluntary imitation accuracy, it would have been predicted that higher ASD traits would be associated with poorer performance on the Imitate task in Chapter 4. However, the finding that performance on the Imitate task was not correlated with any of the independent variables of interest (ASD traits, alexithymia or depression) creates suspicion that this task lacked validity. As described in Chapter 4, participants had particular difficulty with this task, sometimes commenting that the stimuli they were mimicking appeared odd. Future research may benefit from using stimuli that were validated using the FACET software (e.g., stimuli in which FACET detects a high probability that the intended emotion is present and minimal probability that other emotions are present). Finally, it is important to consider that ASD traits were associated with reduced spontaneous expression in some analyses. However, in all such instances, alexithymia, and/or depression fully accounted for the negative relationships between ASD traits and spontaneous expression (analyzed using partial correlations or general linear models).

5.2.2. Depression in Relation to Facial Expression Production

While not examined in Chapter 3, an interest of Chapter 4 was to examine how depression relates to facial expression production. Clinical depression is often accompanied by severe forms of apathy with little emotional reaction to positive or negative events, which contributes to the expression of flat affect (Mayer et al., 1985; Starkstein et al., 2005; Trémeau et al., 2005). Depression was significantly and negatively correlated with several spontaneous expression variables during the story-telling tasks. However, these associations were not independent of the effect of alexithymia. The one instance in which depression was independently associated with spontaneous expression was during the video-watching tasks. Depression was the only significant (and negative) correlate of spontaneous expression in response to the humorous videos. When considering the independent contributions of alexithymia and depression in relation to spontaneous facial expression, an intriguing possibility is that alexithymia is more strongly associated with reduced *negative* expression (as a means to defend against interpersonal conflict and distressing emotions), whereas depression is more strongly associated with reduced *positive* expression (as explained by reduced enjoyment in response to positive events). This pattern of results was found for the video-watching task, but not particularly supported by the pattern of results for the story-telling task. Future research is needed to investigate this possibility further.

Another possibility, is that depression is associated with reduced negative expression, in part, because negative affect such as depression and anxiety elevate scores on measures of alexithymia like the TAS-20 (Taylor et al., 2016), although this possibility would not account for some findings reported in Chapter 4 that depression was independently associated with reduced spontaneous expression irrespective of alexithymia. Given the theoretical consensus that depression and alexithymia are conceptually distinct constructs (Lumley, 2000; Taylor et al., 2016), it remains an interesting question for future research whether the reduced spontaneous use of facial expressions has different or similar mechanisms in relation to alexithymia and depression, respectively.

5.2.3. Alexithymia in Relation to Atypical Facial Expression Production

While, many of the findings presented in this dissertation support traditional theories of social development in ASD, what is missing from these theories is consideration about how impairments in understanding one's own emotions (i.e., alexithymia) may relate to deficits in expressing emotions nonverbally via facial expressions. A key interest of this dissertation was to examine the extent to which alexithymia contributes to reductions in spontaneous facial expression production. It was found that alexithymia was negatively correlated with spontaneous facial expression production among children with ASD (Chapter 3), TD children (Chapter 3), and two subsamples of TD adults (Chapter 4). This section will elaborate on theoretical explanations for why this relationship may exist, particularly in the context of the ASD population.

Interoception

One theory that is growing in popularity explains the etiology of alexithymia as the consequence of a dysfunctional oxytocin system, which in turn leads to impaired interoceptive perception (Brewer et al., 2015; Quattrocki & Friston, 2014). This framework may be useful in explaining why both alexithymia and atypical facial expression production may emerge from a dysfunctional oxytocin system. Quattrocki and Friston present evidence that oxytocin and other neuropeptides mediate *interoceptive perception*—a broad term referring to both conscious and subconscious processing of a variety of bodily states, neural activity, and ongoing cognition, necessary for maintaining homeostasis (Murphy, Brewer, Catmur, & Bird, 2017). To maintain homeostasis, it is necessary for the central nervous system (CNS) to accurately perceive and discriminate interoceptive signals in the Autonomic Nervous System (ANS)—a process which has been termed "interoceptive sensitivity" (Murphy et al., 2017)—in order to regulate affective, cognitive, and other bodily states. Interoceptive signals can range from gut pain (signaling hunger or satiation), temperature (signaling over- or under-heating), and a variety of other sensations such as touch, itch, thirst, nausea, sleepiness, and sexual desire (Quattrocki & Friston, 2014). Relevant to this dissertation work, interoceptive sensitivity is also thought to be critical for identifying and discriminating internal physiological cues of *affect* (Shah et al., 2016), which involves both conscious and subconscious interoceptive processes. When interoceptive failure occurs in this regard, an individual may be left not knowing they are experiencing an emotion and instead mistake physiological indicators of emotion as "physical symptoms," or they may be able to understand they are experiencing an emotion but not be able to discriminate between different emotional categories—both characteristics of alexithymia (Bernhardt, Valk, Silani, Bird, Frith & Singer, 2013; Samson et al., 2012).

In the context of Quattrocki and Friston's (2014) model, the findings from this dissertation may be interpreted in light of the relationship between *interoceptive sensitivity* (in this case, accurate detection and discrimination of physiological cues of affective arousal), and *involuntary motor actions* (in this case, spontaneous facial expressions). Under Quatrocki and Friston's framework, the CNS constructs and refines probabilistic internal models of the world as a result of accumulating life experiences by constantly fine-tuning and updating this internal model as it incorporates new sensory-perceptual evidence (Friston, 2005; Quattrocki & Friston, 2014). Through accurate predictive coding (minimization of predictive errors), the brain is able to make sense of and regulate one's internal world (interoception), external world (exteroception), and use interoceptive and external cues to guide muscular and kinesthetic movement (motor activity and proprioception). To the extent that spontaneous facial expressions measured in this study represent involuntary motor actions, an impaired predictive coding system may contribute to the onset of alexithymia (i.e., failure of the CNS to perceive and discriminate affective arousal in the ANS), which in turn may inhibit automatic motor reflexes such as spontaneous facial expressions, which are operated by a system in the CNS called the extrapyramidal system (Rinn, 1984; Purves et al., 2014; Tassinary & Cacioppo, 2000). In short, an unverified possibility is that an impaired predictive coding system may simultaneously contribute to both alexithymia (impaired interoceptive sensitivity to affective arousal) and involuntary facial expressions (reduced muscular response resulting from affective arousal).

Given its' role in fostering attachment related behaviors in infants, oxytocin is an excellent candidate for facilitating key social processes that are impaired in ASD. In addition to potentially explaining the significantly heightened incidence of alexithymia in the ASD population compared to the general population (Hill et al., 2004), an impaired oxytocin system may trigger atypical developmental processes such as preferentially attending to social over non-social information, and discriminating and selectively choosing the most salient social information, which in turn aids the development of social inferencing and understanding (Quattrocki & Friston, 2014). Indeed, an intriguing evidence base is accumulating demonstrating improvements in desirable social behaviors as a result of nasally administered oxytocin, implying a direct causal role. In persons with

ASD, intravenous or nasal oxytocin administration improves emotion recognition from faces (Anagnostou et al., 2012; Guastella et al., 2010) and vocal tone (Hollander et al., 2007), improvements in communication and social interaction domains of the ADOS (Tachibana et al., 2013), increased activation in select brain regions associated with face processing (Domes, Heinrichs, Kumbier, Grossman, Hauenstein, & Herpertz, 2013), and increased social cooperation and attention to the eye region of faces (Andari et al., 2010). Beyond behavioral research, there is biological evidence indicating that oxytocin levels are found in lower levels in the plasma of ASD compared to TD children (Modahl et al., 1998), and genetic studies have found a link between oxytocin receptor genes and ASD (Wu et al., 2005). To provide empirical support for the theoretical explanation provided here, future research may benefit from investigating whether oxytocin administration may yield improvements in interoceptive sensitivity or more salient and accurate facial expression production in individuals with ASD.

Conflict Hypothesis

In Chapter 3, the 'conflict hypothesis' was proposed as a potential explanation for the relationship between alexithymia and reduced spontaneous facial expression production. This hypothesis conjectures that highly alexithymic individuals have an interpersonal style in which they suppress (consciously) or repress (subconsciously) facial displays of emotion as a means to avoid interpersonal conflict or defend against *intrapersonal* negative affect (Fukunishi & Koyama, 2000; Rasting et al., 2005; Vingerhoets et al., 1995). The conflict hypothesis would also predict that the expression of *positive* affect would be unaffected by alexithymia because positive emotions are generally not associated with conflict (Rasting et al., 2005). Indirect support for this pattern was observed in Chapter 3 such that negative expression, but not positive expression, was negatively associated with alexithymia in children with and without ASD. Similarly, in Chapter 4, reduced positive expression was less strongly associated with alexithymia than negative expression in the story-telling task, and was not significantly associated with alexithymia in the video-watching task. Across studies in this dissertation and the studies reviewed in Chapter 1, alexithymia appears to be more strongly related to reductions in negative rather than positive spontaneous facial expressions, providing indirect support for the conflict hypothesis.

One of the most influential models of emotion regulation postulates that people primarily use one of two strategies to regulate negative emotions in their daily lives: "cognitive reappraisal" or "suppression" (Gross & John, 2003). Cognitive reappraisal is a strategy by which individuals reframe negative events that cause negative emotions into a more positive perspective. For example, after a failed job interview where one may understandably experience negative emotions, that person may respond by dwelling on their personal shortcomings which would exacerbate and extend their experience of negative emotion, or that person could use cognitive reappraisal to reframe the failed interview as an invaluable learning experience and an opportunity for personal growth. Thus, reappraisal intervenes on the emotion trajectory such that it can actually change the emotional response. In contrast, suppression is an emotion regulation strategy that individuals use to distance themselves from negative emotion via distraction, denial, or dissociation from one's own affect, and may be thought of as a "default" strategy for individuals who lack the tools for reappraisal (Gross & John, 2003). For people who use suppression as an emotion regulation strategy, the situational causes of negative emotion may go unsolved, and negative emotions may "fester" without an appropriate outlet or solution, leading to or exacerbating long term personal or interpersonal problems.

There is empirical research demonstrating that individuals with ASD, and individuals with severe alexithymia, are prone to using less effective emotion regulation strategies. Samson et al. (2012) demonstrated that compared to a TD comparison group, participants with ASD were more likely to use suppression as an emotion regulation strategy, and less likely to use cognitive reappraisal. Another study found that a high-alexithymia group was also more likely to use suppression and less likely to use cognitive reappraisal compared to a low-alexithymia group (Swart et al., 2009). Thus, one possible explanation is that heightened levels of alexithymia (Hill et al., 2004) leads people with ASD to use suppression as an emotion regulation strategy, which extends to facial expressions of negative affect.

In order to regulate negative emotions, the first step of this process is an awareness that one is experiencing an emotion—which some individuals high in alexithymia may struggle to do. This lack of emotional awareness may prevent one from "intervening" on the emotional trajectory. Not being consciously aware of one's emotions as they arise or refusing to acknowledge that one is experiencing negative emotions would inhibit one's ability to regulate emotions as they increase in intensity. As a result, individuals with high levels of alexithymia are prone to displaying minimal nonverbal emotional expression most of the time but are also prone to heightened emotional distress or even intense emotional outbursts as distressing emotions increase in intensity (Berenbaum & Irvin, 1996; Haviland & Reise, 1996; Way et al., 2010). This pattern appears consistent with the emotional presentation of individuals with ASD, who are generally less emotionally expressive but are prone to temper tantrums and intense emotional outbursts (Mazefsky et al., 2013; Samson et al., 2012; Jahromi et al., 2012). Thus, it appears that a relative disposition towards ignoring or suppressing one's emotions compounded by poor emotional insight may contribute to emotion regulation problems in ASD (Mazefsky et al., 2013).

The two theoretical accounts proposed above (interoceptive difficulties and the conflict hypothesis) that may explain the relationship between alexithymia and facial expression production are not necessarily contradictory accounts, and elements of both may be useful in explaining the results of Chapters 3 and 4. Reduced *involuntary* displays of emotion as a result of affective arousal (i.e., automatic expression of disgust in response to viewing a toe amputation) may represent the relationship between impaired interoceptive sensitivity and autonomic arousal proposed by Quattrocki and Friston (2014). However, because emotions and their associated autonomic activity (resulting in spontaneous facial expressions) tend to be fleeting (i.e., short in duration; Izard, 1997; Scherer, 2005), a lack of extended displays of facial expressions may be more likely to be a result of suppression. Thus, in consideration of the paradigms used in the present study to elicit emotions (by telling emotional stories or watching emotional video clips), reduced emotional expression may be a combination of reduced interoceptive sensitivity *and* suppression.

5.3. Emotional Expression and Emotion Regulation

As ASD is associated both with atypical emotional expression in addition to emotion regulation difficulties (Majefsky et al., 2013), it is possible that these processes are directly related. If so, interventions that aim to promote emotional expression (verbally or nonverbally) may help to mitigate emotion regulation difficulties and other emotion-related symptoms in individuals with ASD. Here, I argue that the mere act of expressing emotion is, by itself, a regulatory process.

There is an interesting body of research on the “cathartic effects” of emotional expression—which extends to both verbal and nonverbal emotional expression. The act of suppressing an emotion may serve short-term goals of reducing personal distress and interpersonal conflict, but these short-term benefits of suppression may be overshadowed by long-term adverse mental and physical health outcomes. For example, abused children are less facially and verbally expressive, presumably because these children learn to inhibit negative facial displays and speech to avoid maltreatment (Gaensbauer & Sands, 1979). While this strategy may prevent further distancing themselves from their caregivers in the short-term, children who have disorganized or insecure attachment patterns with their caregivers have higher levels of alexithymia, possibly as a result of distancing themselves from their inner emotions (Lemche, Klann-Delius, Koch, & Joraschky, 2004). Berry and Pennebaker (1993) reviewed a number of studies demonstrating that people who are generally less emotionally expressive tend to have more adverse psychological, physiological, and physical health symptoms. Questionnaire studies have shown that of people who have experienced trauma in childhood (e.g., the death of a relative, divorce of parents, sexual trauma), those who disclosed their traumas to fewer people were more likely to be diagnosed with cancer, high blood pressure, ulcers, and other major and minor health problems (Pennebaker, 1989, 1990). Studies that require participants to journal about traumatic events for 15-20 minutes per day for 3-5 consecutive days compared to participants who journaled about trivial topics (controlling for prior differences in health), required significantly fewer visits to the doctor (2-4 months after study). Journaling about traumatic events also enhanced immune function as measured by blood samples (Pennebaker & Beall, 1986; Pennebaker, Colder & Sharp, 1990; Pennebaker, Kiecolt-Glaser & Glaser, 1988).

Why is emotional expression associated with better health outcomes? A study where participants attempted to suppress nonverbal emotional displays during a guilty knowledge task found that active suppression of emotional displays *increases* autonomic activity as measured by skin conductance response, indicating a more severe stress response (Pennebaker & Chow, 1985). When talking about personal traumatic experiences, participants who were categorized as "low-disclosers" by independent raters based on how personal and stressful their stories were exhibited higher skin conductance levels compared to "high-disclosers." (Pennebaker, Hughes, & O-Heeron, 1987). Together, these findings suggest that when such nonverbal responses are suppressed, they in effect go underground and are expressed covertly through increased autonomic arousal (Pennebaker, 1993). Indeed, some scholars have suggested that in persons high in alexithymia who have a disposition towards inhibiting verbal and nonverbal emotional expression, negative emotions may fester, leading to the well-documented health challenges associated with alexithymia including psychosomatic symptoms, physical illness, and mood disorders such as depression and anxiety (Murphy et al., 2017). For individuals with severe alexithymia, life problems go unresolved without the appropriate outlets for negative emotion, and without effective strategies for solving emotional problems.

5.4. Implications for Practitioners

While the foci of Chapters 3 and 4 of this dissertation were on the relations between alexithymia and nonverbal communication of emotion in individuals with and without ASD, an important area for future research is to examine how alexithymia impacts the broader spectrum of emotional health of individuals with ASD. Severe depression and anxiety in ASD are among the most common causes for hospitalization, psychiatric services and medication, and intense emotional outbursts present a major concern for parents and caregivers because of the safety risks they pose to the individual and others in their environment (Mandell, 2008; Mazefsky et al., 2013; Simonoff, Pickles, Charman, Chandler, Loucas, & Baird 2008). Hence, there is a need for interventions designed towards helping children with ASD understand and manage negative emotions, as well as being able to communicate emotions verbally and nonverbally. Such initiatives are important to parents and caregivers of individuals with ASD and have the potential to ameliorate highly common emotion regulation difficulties that can lead to emotional outbursts, depression or anxiety.

This dissertation research, in combination with prior research on alexithymia, suggests that alexithymia may be a prime candidate for contributing to difficulties communicating and regulating emotions in ASD. Therefore, interventions for serving individuals with ASD may benefit from targeting alexithymia as a potential modifiable pathway for promoting emotional health and other social-emotional competencies.

5.4.1. Child Interventions

Accurate nonverbal emotional expression may be of particular developmental significance during childhood. Buck and Powers (2013) hypothesize that when children express emotions verbally and nonverbally, the ways in which caregivers respond to those emotions serve as educational opportunities in a process the authors call "biosocial feedback," helping children to understand what emotions they are experiencing, the events that lead to negative emotions, and strategies for regulating those emotions. Buck and Powers suggest that if children have a disposition towards suppressing emotional expression, or do not clearly express their emotions, social and emotional learning opportunities are lost through compromised biosocial feedback. For example, if a young boy expresses frustration playing a game that is too advanced for him, a caregiver may respond in such a way that helps the child understand what emotion he is experiencing, why he is experiencing it, and may subsequently offer strategies on how to regulate that specific emotion. If children are reluctant to express their emotions, or if they express them in confusing ways, learning opportunities through biosocial feedback are lost and alexithymia could develop over time. Thus, throughout development, alexithymia and impaired emotional expression may impact each other bi-directionally such that alexithymia reduces the spontaneous use of nonverbal emotional expression, and a lack of nonverbal expression leads to impaired emotional understanding due to less quality feedback from their environment. This pattern may be a particular concern for children with ASD given the confusing and diminished emotion expression patterns they are prone to displaying (Capps et al., 1993; Dawson et al., 1990; Snow et al., 1987). Irrespective of the child's expressivity, Buck and Powers' hypothesis points to the potential for designing parent-mediated interventions with the goal of fostering children's emotional understanding by encouraging verbal and nonverbal emotional expression and providing educational feedback about their emotions that aids their emotional development. Such interventions may be effective for decreasing the risk of alexithymia over time.

Another approach is to use interventions that directly target facial expression abilities. Given that facial expressions represent an important facet of social communication, whether or not accurate facial expression production can be explicitly taught to persons with ASD is worth investigating. Gordon et al. (2014) attempted to train facial expression production abilities in children with ASD and TD children matched on age and IQ using an application-based game called "FaceMaze." FaceMaze requires participants to express two emotional facial expressions—happiness or anger—at various checkpoints to advance through a maze within the game. Participants' facial expressions were analyzed using automated, image-based facial movement detection algorithms with the Computer Expression Recognition Toolbox (CERT; Littlewort et al., 2011). The game only allowed participants to advance through the checkpoints if the software detected movement in the zygomaticus major, signaled by upper inflection of the lip for the happy expression, or movement in the corrugator supercilii resulting in furrowing of the brow for the angry expression. In addition to these automated algorithms, the quality of participants' facial expressions for anger, happiness, and a third emotion—surprise (added as a control condition)—were rated by undergraduate students (blind to the aims of the study and diagnosis of the participants) before and after participants engaged with FaceMaze for several minutes. Pre-post comparisons in subjective ratings revealed that both ASD and TD participants yielded significant gains in quality of expression for anger and happiness, but not for surprise, which led the authors to suggest that the improvements may be due to direct training effects of FaceMaze. Additionally, post-intervention ratings revealed that the expressions of participants with ASD were rated as equal (for happiness) or better (for anger) in “quality” compared to the TD children at post-intervention, despite worse (for happiness) or equal (for anger) quality compared to TD children pre-intervention. However, it is possible that gains in the ASD group may be a result of maturation effects (i.e., due to normal developmental changes over the passage of time unrelated to the intervention) or regression to the mean. This intervention looks promising as an easily implemented low-cost intervention approach to improve facial expression production abilities in children with ASD; however, studies with randomized control designs are needed to assess the efficacy of the intervention.

5.4.2. Adolescent and Adult Interventions

In order to regulate one’s emotions, one must a) be aware that an emotion is arising in the self before one can intervene on the emotion trajectory, and b) possess effective cognitive strategies for minimizing negative emotional responses to unfavorable events (Gross & John, 2003; Swart et al., 2009). The degree to which alexithymia affects social competencies and emotional health in individuals with ASD has received little attention. If alexithymia stems in part from an impairment in interoceptive sensitivity (Quattrocki & Friston, 2014), then it stands to reason that interventions aimed at improving sensitivity to one’s bodily cues of affect may promote emotional awareness and potentially decrease alexithymia.

Over the last two decades, Western therapeutic practices have increasingly drawn from contemplative practices of Buddhist traditions such as Mindfulness and Meditation into interventions such as “Mindfulness-based Stress Reduction” (MBSR) and “Mindfulness-based Cognitive Therapy” (MBCT). Mindfulness has been defined as, “The awareness that emerges through paying attention on purpose, in the present moment, and nonjudgmentally to the unfolding of experience moment by moment” (Kabat-Zinn, 2003, p. 145). It incorporates formal practices such as meditation that are undertaken for specific periods of time, but also informal practices that incorporate lessons from meditation into daily life by living “mindfully” by maintaining awareness of one’s ongoing stream of consciousness and evolving emotional and physical feelings. A study that reviewed relevant intervention studies suggests that many studies to date that have investigated the effectiveness of MBSR and MBCT suffer from non-optimal research designs (e.g., no control group, short interventions), but that preliminary findings suggest MBSR and MBCT are more or similarly effective compared to traditional therapeutic practices for improving mental health and decreasing the risk of depression relapse in clinical patients (Fjorback, Arendt, Ørnbøl, Fink, & Walach, 2011). These interventions are increasingly used in the ASD community and are efficacious in treating depression and anxiety in adults with ASD (Spek, Van Ham, & Nyklíček, 2013), in minimizing aggressive behavior in physically aggressive adolescents with ASD (Singh et al., 2011), and for decreasing stress and improving other health outcomes in parents of children with ASD who experience high degrees of parental stress (Ferraioli & Harris, 2013).

Research is needed to examine how contemplative practices such as Mindfulness and Meditation strategies may be useful in increasing interoceptive sensitivity and ameliorating alexithymia in ASD. Recently, Bornemann and Singer (2017) implemented an intervention of contemplative practices over a 9-month period including 13 weekly group sessions of two hours each, a 3-day silent retreat, and about 30 minutes of daily practice in a sample of 332 TD participants. The training was facilitated by expert meditation teachers and psychotherapists and supported by a smartphone app. The 9-month intervention was broken down into three separate 3-month modules: 1) "Presence," which uses Breathing Meditation and Body Scan approaches to teach participants to live within the ever-unfolding present moment, and mitigate urges to dwell on the past or worry about the future; 2) "Affect," in which participants learn "Loving-kindness Meditation" and engage in contemplative dyadic exercises to approach difficult emotions with acceptance and compassion, and to promote prosocial attitudes of kindness and care towards themselves and others; and 3) "Perspective," in which participants practice a form of meditation that involves observing their own thoughts and thinking patterns, as well as attempting to re-experience a recent situation from a different perspective or taking the perspective of a dyadic partner. A consistent theme throughout all of these modules was a focus on breath and body sensations as a means for returning to focus on the present moment when attention to the meditation practice at hand had strayed. The researchers measured alexithymia (as measured by the TAS-20), and interoceptive sensitivity (as measured by heart-beat perception tasks) at four time-points (0, 3, 6 and 9 months) and found steady decreases in alexithymia and increases in interoceptive sensitivity in the treatment groups compared to waitlist controls. Future research should aim to replicate these findings in participants with ASD, complemented by an examination of how potential changes in alexithymia and interoceptive sensitivity may relate to changes in anxiety, depression, emotion regulation, verbal and nonverbal emotional expression (e.g., facial expressiveness), and other social-emotional characteristics of ASD.

5.5. Evaluating the Alexithymia Hypothesis

One of the most pressing challenges facing researchers who study ASD is the phenotypic heterogeneity that exists in this population. This heterogeneity, at least in part, contributes to the equivocal pattern of empirical findings observed in the ASD literature, which significantly diminishes our ability to use empirical research to generate clinical, educational and policy implications. Thus, a priority for ASD researchers (and the journals who publish ASD research), is to carefully detail participant demographic information of each research study so that researchers can use matching procedures and statistical methods such as mediation and moderation to control for the effects of participant demographics within studies, and across studies using meta-analysis (Amaral et al., 2016).

While the reporting of demographic information such as age, intellectual functioning, and characterizations of diagnostic severity with the use of gold-star tools such as the ADOS and ADI-R are common practice in empirical ASD research, Bird and Cook (2013) suggest alexithymia should be reported as routinely as age and intelligence in studies that examine emotion-related processes so that a literature base can develop to fully elucidate the extent to which alexithymia drives heterogeneity in social-emotional characteristics of ASD. For example, Harms et al., (2010) reviewed a large number of studies on emotion recognition abilities in individuals with ASD compared to TD comparison groups and reported large heterogeneity in findings; some studies found large emotion recognition deficits in ASD, with others found no group differences. In light of

Cook et al.’s (2013) findings that alexithymia may account for emotion recognition deficits in ASD, varying levels of alexithymia in participants with ASD within the studies reviewed by Harms et al., (2010) may account for the equivocal research findings, although it is impossible to know without having levels of alexithymia measured in those studies. Alexithymia can be measured using freely accessible and well-validated questionnaires such as the Toronto Alexithymia Scale (TAS-20), or the Children’s Alexithymia Measure (CAM), and can be administered in a few minutes, making them highly cost-effective in terms of time and financial investment.

5.5.1. Merits of the Alexithymia Hypothesis

One of the strengths of the alexithymia hypothesis is the causal-comparative nature of research designs that can be used to investigate this hypothesis. While causation cannot be fully established without experimentally manipulating variables, comparing studies that match ASD and comparison groups on levels of alexithymia versus studies that do not match ASD and comparison groups helps to determine the extent that alexithymia may influence other social-emotional variables. For example, when matching ASD and TD groups on levels of alexithymia and comparing their performance on an emotion recognition task, if group differences are nonsignificant (as was found in Cook et al., 2013), then in combination with studies that do find ASD deficits in emotion recognition that do not match on alexithymia, the pattern of results provides evidence that alexithymia may have a causal role in emotion recognition abilities in ASD. Matching ASD and comparison groups on alexithymia can also be helpful for determining which social-emotional impairments may *not* be due to alexithymia, in situations where group differences on dependent variables remain.

While it is not yet clear how influential research in this area will be in aiding our understanding of ASD, there is a noteworthy potential of the alexithymia hypothesis to better our understanding of the heterogeneity in the ASD phenotype. If future research on the alexithymia hypothesis continues to find that roughly half of the ASD population is affected by severe alexithymia, and that these alexithymia traits account for a specific subset of emotion-related processing abnormalities in ASD, then the presence or absence of alexithymia may be useful for subtyping the ASD population for research and clinical purposes. However, there are several major limitations and unresolved questions related to the alexithymia hypothesis that may limit the utility of this line of research that are detailed in the following subsections.

5.5.2. Measurement Issues

The most widely used tool to assess alexithymia in research contexts is the self-report TAS-20 (Bagby et al. 1994). While the TAS-20 has been extensively validated and has contributed immensely to empirical research on the alexithymia construct, self-report measures create a concerning question of whether individuals with severe levels of alexithymia possess enough emotional awareness to accurately reflect and characterize their own emotional awareness (Lane, Weihs, Herring, Hishaw, & Smith, 2015). For example, it is possible that individuals with severe alexithymia may not know that they lack certain capacities that self-report tools like the TAS-20 attempt to measure (Taylor, Bagby, & Parker, 2016). For this reason, leading alexithymia scholars have argued that alexithymia research is optimized by the use of multi-method approaches (Taylor & Bagby, 2004a; Taylor, et al., 2016)—for example, with the use of structured interview methods such as the modified version of the Beth Israel Hospital Psychosomatic Questionnaire (Taylor, Bagby, & Parker, 1997) or the Toronto Structured Interview for Alexithymia (Bagby, Taylor, Parker, & Dickens, 2006). However, prior research has shown that many individuals with ASD have limited self-reflection (Kennedy & Courchesne, 2008; Lombardo, Barnes, Wheelwright, & Baron-Cohen, 2007). In addition, qualitative researchers have commented that the social and communication deficits characteristic of ASD present inherent challenges with the face-to-face format of interview research methods in this population (Armstrong, 2011; Roberts & Birmingham, 2017). Thus, is it remains an urgent priority for future research to investigate whether traditional self-report and interview methods for estimating alexithymic tendencies are appropriate for research in ASD.

Parent-report questionnaires present another option that may be particularly useful for assessing childhood alexithymia. However, parents of children with ASD often have high levels of alexithymia (Szatmari, Georgiades, Duku, Zwaigenbaum, Goldberg, & Bennett, 2008), which raises the question of how accurately they can report on their children's alexithymic tendencies. Indeed, Griffin et al. (2016) found nonsignificant correlations between parent-report and self-report measures of alexithymia in children with ASD, suggesting that a) these measures are tapping into conceptually distinct constructs, b) children and parents are drawing from different sources of information to complete these questionnaires, or c) children or parents are inaccurately completing these questionnaires. Relatedly, the parent-report CAM (used in Chapter 3) was validated in a sample of TD children who had experienced trauma (Way et al., 2010), and the TAS-20 (used in Chapter 4) was validated in community samples of TD adults in the general population (Bagby et al., 1994; Taylor, Bagby, & Parker, 2003). These measures have been used sporadically in participants with ASD, but measurement tools are considered valid only in the population in which they were validated (Furr & Bacharach, 2013). The validation of these tools in ASD samples remains an urgent priority for future research.

Finally, it is important to consider that the alexithymia construct has a verbal ability component. If a boy with ASD does not talk about his emotions, is it because he cannot reflect and understand his own emotions, or does he lack the vocabulary or social communication abilities to describe his emotions? This consideration is particularly important for research in ASD, given the well-established verbal delays in many children with ASD (Anderson et al., 2007) that sometimes persist into adulthood. This potential confound can be controlled for, somewhat, by assessing verbal intelligence. For example, results of Chapter 3 found that the ASD and TD groups were matched on vocabulary abilities despite large group differences in alexithymia. Still, an important consideration for future research is to determine how to conceptualize and operationalize alexithymia in individuals with ASD who have verbal deficits.

5.5.3. Is Alexithymia Really Dissociable from ASD?

The alexithymia hypothesis hinges on the assumption that alexithymia and ASD are distinct conditions. Bird and Cook (2013) provide several reasons to support this claim which will be evaluated separately. Bird and Cook emphasize that alexithymia is not *specific* to ASD—it is associated with a number of other clinical disorders and is prevalent within the general population (Murphy et al., 2017). They also go on to argue that it is not *universal* within the ASD population, such that not all individuals with ASD are afflicted by severe alexithymia (Hill et al., 2004). This argument is not particularly compelling given that many characteristics of ASD listed in the DSM-5 are neither universal (an ASD diagnosis requires the presence of only a portion of the characteristics listed) nor specific to ASD. Furthermore, the prevalence of alexithymia in the ASD population has not been sufficiently researched. The oft-cited assumption that approximately 50% of the ASD population has 'severe alexithymia' was based on the finding from Hill et al. (2004) that 13 out of 27 of their ASD participants had a score of 61 or higher on the TAS-20 (cut-off score for 'severe impairment' reported in Bagby et al., 1994). This sample size is well below what would be considered an epidemiological study and is based on a non-representative sample of participants with ASD described as "high-functioning adults," although no estimates of intellectual functioning were reported. In short, the actual prevalence of severe alexithymia in ASD remains unknown.

Bird and Cook (2013) review evidence that the neural underpinnings of alexithymia may be distinct from that of ASD. Alexithymia has most often been associated with reduced activation in the anterior insula (AI) and anterior cingulate cortex (ACC)—brain networks associated with interoception and empathy among other functions (Bird et al., 2010; Bird & Cook, 2013). In contrast, autism symptom severity has been associated with coherence of networks including the medial prefrontal and temporoparietal cortices (Bernhardt et al., 2013). However, Bird and Cook are cautious in stating that the respective neural substrates of alexithymia and ASD are not well enough understood, and that they are unlikely to have entirely distinct origins. Though they cite no specific evidence for this, they speculate that both ASD and alexithymia are associated with suboptimal neural connectivity. When suboptimal neural connectivity predominantly affects singular brain regions, a 'pure' ASD or alexithymic phenotype may result, but it is more likely that poor connectivity may extend to multiple brain regions as a result of common genetic and environmental risk factors, resulting in the high co-occurrence between alexithymia and ASD.

There is another emerging line of research that is important to consider when determining whether ASD and alexithymia are dissociable. Quattrocki and Friston's model (2014) outlines a developmental trajectory such that a dysfunctional oxytocin system leads to impaired interoceptive abilities, which in turn lead to the social-emotional and other cognitive and behavioral manifestations of ASD. If this were the case, then it must logically follow that individuals with ASD must have persistent and universal deficits in interoception. A great deal more work is needed to investigate this possibility, and while the existing evidence is far from conclusive, there is no clear pattern of interoceptive deficits in ASD. To my knowledge, there are four existing studies that have investigated interoception in ASD—one study found impaired interoceptive perception in participants with ASD (Fiene & Brownlow, 2015), one found no group differences (Shah et al., 2016), one found *heightened* interoceptive perception in participants with ASD (Schauder et al., 2015), and one found heightened *and* impaired interoception in participants with ASD depending on the measurement method (Garfinkel et al., 2016), compared to TD comparison groups.

Fiene and Brownslow (2015) examined self-reported interoceptive perception and found that participants with ASD report less awareness of thirst and other bodily cues, such as internal temperature, hunger, muscle soreness and temporal changes of such stages over time compared to an unmatched TD comparison group. In contrast, Garfinkel et al. (2016) found *heightened* interoceptive sensibility in their ASD group as measured by self-report questionnaires in relation to a comparison group matched on age and gender, but *lower* interoceptive sensitivity as measured by the aforementioned heartbeat tracking and discrimination tasks. In conjunction, this discrepancy between self-reported and actual interoceptive ability points to a significantly reduced *interoceptive awareness* in the ASD group (Garfinkel et al., 2016), reflecting less accurate judgments of their own interoceptive abilities. In contrast to Garfinkel et al.'s (2016) findings, Schauder et al. (2015) found heightened interoceptive sensitivity in a sample of children with ASD compared to a group of age and IQ matched TD comparisons as measured by the heartbeat perception tasks, but only at longer time intervals, suggesting children with ASD have better *sustained* attention to internal cues.

Finally, Shah et al., (2016) found no group differences between ASD and control groups matched on levels of alexithymia (and age, gender and IQ) on the heartbeat tracking tasks. Critically, Shah et al.'s study found that performance on the heartbeat tracking task was negatively associated with alexithymia, but not associated with ASD traits. In sum, the few studies and equivocal findings on interoception in ASD provide no conclusive support for Quattrocki and Friston's (2014) supposition that ASD emerges from interoceptive failures, and it is more likely that interoceptive difficulties underlie alexithymia, not ASD (Brewer et al., 2015; Shah et al., 2016). Therefore, if future research finds that interoceptive difficulties are present only in a subset of the ASD population, but is more strongly predictive of alexithymia, this would strengthen Bird and Cook's claim that ASD and alexithymia are dissociable.

5.6. Limitations

Here, I detail several methodological limitations of the studies presented in this dissertation with an eye towards proposing ideas that may advance future research in this area. First, technologies like FACET are in urgent need of validation studies as well as guidelines for how to use these technologies for scientific research. FACET was originally designed for market research—for example, for businesses to examine emotional reactions of consumers as they view advertisements or as they interact with games, programs or other computerized technologies. FACET offers market-based researchers a convenient solution for analyzing large quantities of consumer behavior to answer basic questions about whether advertisements are producing the desired emotional reactions in viewers, and whether interactions with various programs result in satisfaction or frustration. The types of questions scientific researchers are concerned with require much more consideration of experimental control and potential confounds. As described in Chapter 4, a large quantity of lost data resulted from a failure of FACET to get reliable readings of participants' faces, which may have been due to several factors such as distance between cameras and the faces, lighting in the room, movement and tilt of the head, and individual differences of the participants such as sex, ethnicity, facial hair, and piercings (to name just a few). Moreover, as the data collection process unfolded, and lessons were learned regarding optimal participant positioning and instructions, a negative outcome of requesting participants to stay still and not move their head was that their natural behavior become increasingly compromised as piloting revealed that being instructed to stay still was sometimes interpreted as a need to also suppress facial displays. Thus, research is needed to identify optimal participant instructions for maximizing experimental control without trading off too much naturalistic behavior.

Relatedly, as findings from Chapter 2 revealed that ASD-comparison group differences in facial expressions were larger in paradigms in which facial expressions were implicitly elicited versus paradigms in which facial expressions were explicitly elicited, research using FACET software must consider ways researchers can assess real-world behavior within the confines of a laboratory. Indeed, the tasks used in this study—telling personal stories to an experimenter, watching video clips, or artificially posing facial expression in various tasks, may not fairly approximate how individuals produce spontaneous and voluntary facial expressions in their daily lives. Trying to replicate real-world behavior is inherently challenging, if not impossible, for use with FACET as this technology requires close proximity between an individual's face and a stationary camera. Perhaps research that requires participants to interact with friends or family members via Skype or other video-call applications may help answer questions about how individuals spontaneously or voluntarily express facial displays in authentic social interactions to regulate verbal exchanges.

There is also a need to develop better methods for assessing voluntary expression accuracy and expression quality. Previous research has used subjective ratings (e.g., Likert scales of raters assessing "quality" or "awkwardness" of expressions. These subjective ratings may have ecological validity in the sense that others' perceptions of facial expression quality are important for how these perceptions impact the quality of social interactions. However, subjective ratings may be most useful as a complement to more objective measurement strategies. For example, some researchers have used objective tests that examine whether one group of "rating" participants can correctly identify the intended emotional expression of "posing" participants (e.g., Brewer et al, 2016; Faso et al., 2015). However, as Faso et al. (2015) learned, individuals may use compensatory strategies like expressing emotions in an exaggerated fashion—which may help others understand the intended emotion but may still negatively impact social interaction quality if the exaggerated expressions appear awkward or unusual.

In Chapter 4, I used a novel method to assess voluntary expression accuracy using automatic facial expression analysis software to detect whether the intended emotional expression was the dominant emotion detected by the software. This approach appears to have some validity based on the fact that voluntary expression accuracy measured in this way correlated with alexithymia, depression, and ASD traits in theoretically expected ways. However, this approach is limited by the rather crude approach of measuring accuracy on a dichotomous continuum of “correct” or “incorrect” trials. To reduce unnecessary loss of fine-grained data, future methods may benefit from utilizing FACET to measure voluntary expression accuracy continuously. For example, Brewer, Trevisan and Bird (in preparation) developed a technique in which the probability threshold of a target emotion can be divided by the sum of the target emotion threshold plus the sum of the probability thresholds of all other present non-targeted emotional expressions. Preliminary analyses indicate that this method has shown better accuracy than the method used in Chapter 4 based on its ability to discriminate ASD and TD comparison groups, and stronger correlations with theoretically relevant variables of interest.

While the studies presented in this dissertation provide relatively consistent results that alexithymia is negatively correlated with spontaneous facial expressions, there is still a need to understand *why* this relationship exists. In this chapter, two possible theoretical explanations were offered—the conflict hypothesis, which suggests highly alexithymic individuals will suppress or repress facial displays to distance themselves from distressing emotions or to avoid interpersonal conflict, and the interoception account, which suggests impairments in interoceptive sensitivity of emotion will mitigate corresponding motor responses (in this case, spontaneous facial expressions) that normally arise from affective arousal. An important element of both of these accounts is that the negative association between alexithymia and spontaneous facial expressions must be considered only when individuals are experiencing *affective arousal.* In an effort to elicit affective arousal, Chapters 3 and 4 relied on two paradigms—watching emotional video clips or telling stories about their personal lives. Caution is warranted with respect to whether spontaneous expression in these tasks exclusively represents affective arousal because emotional expression during these tasks could represent other processes. For example, there was a “social” element of the story-telling task, such that participants could have been voluntarily manipulating their own emotional expressions for a real or “imagined” audience—even if there was no listener in the room. As indicated in Chapter 4, FACET detected more positive emotion than negative emotion during the story-telling tasks, even for the negative story, suggesting expressions may not purely be a by-product of emotions experienced during the story. Emotions activated by the ANS and corresponding automatic facial expressions tend to be fleeting (Scherer, 2005; Izard, 1997). Thus, it is questionable whether ongoing emotional expression while watching movies or telling stories purely reflects autonomic arousal. Therefore, future research may benefit from use of different paradigms that may help to investigate different theoretical accounts. For example, in some studies synthesized in Chapter 2 that examined ASD-comparison group differences in spontaneous facial expression production (e.g., Legiša, Messinger, Kermol, & Marlier, 2013), participants were exposed to pleasant and disgusting odors. It may be useful to extend this paradigm to understanding associations between alexithymia and spontaneous facial expression. One could argue that in this non-social context (exposure to an odor), reduced facial expression would not be indicative of a desire to defend against negative affect or avoid interpersonal conflict. Rather, if alexithymia is associated with reduced spontaneous expression in response to odors, it would be better explained by the interoceptive accounts (i.e., reduced connectivity between affective arousal in the ANS and motor reflexes operated by the extrapyramidal system in the CNS).

5.7. Conclusion

I agree with Bird and Cook’s (2013) assertion that alexithymia should be considered distinct from that of ASD for one specific, pragmatic reason. ASD is currently defined and diagnosed based on the presence and cluster of *behavioral* symptoms, whereas alexithymia represents atypical emotional and cognitive processes. Certainly, alexithymia appears to be associated with a certain pattern of behaviors—the empirical evidence provided and reviewed in this dissertation suggests decreased verbal and nonverbal emotional expression in conjunction with occasional difficulties regulating intense emotions (e.g., emotional outbursts) may characterize the behavioral phenotype of alexithymia. However, it could be argued that these symptoms overlap substantially with existing ASD symptomology related to reduced social-emotional reciprocity, atypical use of nonverbal communication, and emotion dysregulation. What may be an effective approach is for clinicians to routinely consider alexithymia as part of the broader clinical profile of individuals with ASD. For example, anxiety and depression are considered distinct from that of ASD despite their strong co-occurrence. Perhaps alexithymia should be considered along with depression and anxiety in characterizing the emotional health of individuals with ASD. Initial investigations of alexithymia in ASD suggest that alexithymia may be useful in explaining heterogeneity in symptom presentation within the ASD population, and future research is urgently needed to determine whether the presence or absence of severe alexithymia may be useful in determining optimal interventions. I enthusiastically reiterate Bird and Cook's (2013) conclusion about the alexithymia construct in the context of ASD research:

> "…one thing is clear; this intriguing condition demands considerably more research attention than it currently receives." (p. 6).

Emotional understanding and emotional expression is at the forefront of parents' minds, given its impact on daily life. Thus, a priority of researchers and clinicians should be to help children with ASD understand, communicate, and manage their negative emotions. Such initiatives are intuitively important to parents and have the potential to ameliorate short-term (emotional outbursts) and long-term (depression and anxiety) emotional problems that commonly afflict individuals with ASD. The research presented in this dissertation provides an important step towards this ambitious mission by advancing understanding of how individuals with ASD express emotions atypically and by providing the first empirical evidence that atypical facial expression production in individuals with ASD may be influenced by alexithymia. I look forward to conducting future research with the aim of designing and evaluating tools and interventions that help children with ASD articulate and regulate their emotions; thereby minimizing the risk of chronic emotion processing conditions and unlocking the possibility for parents to form more meaningful emotional connections with their children that so many yearn for.

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Appendix A.

Description of Video Stimuli used in Chapter 3

Name of Video	**Scene Description**	**Primary Emotion**	**Secondary Emotion(s)**	**Clip Duration (seconds)**
Tangled	Rapunzel discovers she is the lost princess, kidnapped at birth by Mother Gothel (who Rapunzel believed to be her real mother) to exploit Rapunzel's powers in order to stay young. During the scene, Rapunzel confronts Mother Gothel and a heated argument ensues.	Anger	Fear, contempt	114
Inside Out	The character, Riley, and her personalized emotion character, Disgust, make multiple expressions of disgust as Riley swats a fly with a paper and peers underneath.	Disgust	NA	25
Monsters Inc.	The character, James P. Sullivan, has to say goodbye forever to his young friend Boo.	Sadness	NA	38
All Dogs Go To Heaven	The character, Charles B. Barkin, encounters all sorts of evils in the depths of hell during a nightmare.	Fear	NA	87
Shrek	Introductory scene showing the character, Shrek's, unhygienic living conditions.	Disgust	Joy	82
A Conversation with Koko	The narrator describes a sad event where Koko's beloved pet cat, Allball, was tragically killed by a car.	Sadness	NA	120
"Tennis Cats" (Youtube)	Four kittens move their heads in unison as their gaze follows the movement of an unknown object from behind the camera	Joy	NA	23
"Best of BBC Talking Animals" (Youtube)	Parodies of a nature show that dubs human voices over the clips as if the animals are talking to each other	Joy	NA	98

Name of Video	Scene Description	Primary Emotion	Secondary Emotion(s)	Clip Duration (seconds)
“Hysterical Bubbles! – laughing baby (Youtube)	A baby laughs hysterically as a dog gleefully pops bubbles with her mouth blown by the baby’s mother.	Joy	NA	27
Emotional Baby! Too Cute! (Youtube)	A baby smiles and cries in response to her mother singing a sad song.	Joy	Sadness	53

Note. The use of portions of copyrighted material for the purposes of research is both legal and ethical under the provisions of *CCH Canadian Ltd. v. Law Society of Upper Canada* (2004).

Appendix B.

Questionnaires used in Chapter 3

Autism Spectrum Quotient (AQ) – Child Version

	Definitely Agree	**Slightly Agree**	**Slightly Disagree**	**Definitely Disagree**
S/he prefers to do things with others rather than on her/his own.				
S/he prefers to do things the same way over and over again.				
If s/he tries to imagine something, s/he finds it very easy to create a picture in her/his mind.				
S/he frequently gets so strongly absorbed in one thing that s/he loses sight of other things.				
S/he often notices small sounds when others do not.				
S/he usually notices house numbers or similar strings of information.				
S/he has difficulty understanding rules for polite behaviour.				
When s/he is read a story, s/he can easily imagine what the characters might look like.				
S/he is fascinated by dates.				
In a social group, s/he can easily keep track of several different people's conversations.				
S/he finds social situations easy.				
S/he tends to notice details that others do not.				
S/he would rather go to a library than a birthday party.				
S/he finds making up stories easy.				
S/he is drawn more strongly to people than to things.				

	Definitely Agree	Slightly Agree	Slightly Disagree	Definitely Disagree
S/he tends to have very strong interests, which s/he gets upset about if s/he can't pursue.				
S/he enjoys social chit-chat.				
When s/he talks, it isn't always easy for others to get a word in edgeways.				
S/he is fascinated by numbers.				
When s/he is read a story, s/he finds it difficult to work out the characters' intentions or feelings.				
S/he doesn't particularly enjoy fictional stories.				
S/he finds it hard to make new friends.				
S/he notices patterns in things all the time.				
S/he would rather go to the cinema than a museum.				
It does not upset him/her if his/her daily routine is disturbed.				
S/he doesn't know how to keep a conversation going with her/his peers.				
S/he finds it easy to "read between the lines" when someone is talking to her/him.				
S/he usually concentrates more on the whole picture, rather than the small details.				
S/he is not very good at remembering phone numbers.				
S/he doesn't usually notice small changes in a situation, or a person's appearance.				
S/he knows how to tell if someone listening to him/her is getting bored.				
S/he finds it easy to go back and forth between different activities.				
When s/he talk on the phone, s/he is not sure when it's her/his turn to speak.				
S/he enjoys doing things spontaneously.				
S/he is often the last to understand the point of a joke.				

	Definitely Agree	Slightly Agree	Slightly Disagree	Definitely Disagree
S/he finds it easy to work out what someone is thinking or feeling just by looking at their face.				
If there is an interruption, s/he can switch back to what s/he was doing very quickly.				
S/he is good at social chit-chat.				
People often tell her/him that s/he keeps going on and on about the same thing.				
When s/he was in preschool, s/he used to enjoy playing games involving pretending with other children.				
S/he likes to collect information about categories of things (e.g. types of car, types of bird, types of train, types of plant, etc.).				
S/he finds it difficult to imagine what it would be like to be someone else.				
S/he likes to plan any activities s/he participates in carefully.				
S/he enjoys social occasions.				
S/he finds it difficult to work out people's intentions.				
New situations make him/her anxious.				
S/he enjoys meeting new people.				
S/he is good at taking care not to hurt other people's feelings.				
S/he is not very good at remembering people's date of birth.				
S/he finds it very to easy to play games with children that involve pretending.				

Reversely keyed items: 1, 3, 8, 10, 11, 14, 15, 17, 24, 25, 27, 28, 29, 30, 31, 32, 34, 36, 37, 38, 40, 44, 47, 48, 49, 50

Children's Alexithymia Measure

		Almost Never	Sometimes	Often	Almost always
1.	When asked about how he/she is feeling, instead talks about what he/she has been doing				
2.	Has difficulty saying he/she feels sad even though he/she looks sad				
3.	Talks about unimportant things/topics instead of sharing his/her feelings				
4.	Has long periods of little or no emotional expression, interrupted by bursts of emotional expression				
5.	Has difficulty saying he/she is happy even though he/she looks happy				
6.	Physically removes self from situations when asked to talk about feelings				
7.	Makes up unrelated stories when asked about his/her feelings				
8.	Verbal expressions of feelings do not match non-verbal expressions of feelings				
9.	Changes the topic of conversation when asked about his/her feelings				
10.	Has difficulty naming his/her positive feelings (such as joy, happiness, excitement)				
11.	Says "forget it" or "leave me alone" when asked about his/her feelings				
12.	Has trouble finding words or getting words out when talking about his/her own feelings				
13.	Uses few words (may just say "good" / "bad") to describe most of his/her feelings				
14.	Says "I don't know" when asked why he/she is upset				

Appendix C.

Description of Video Stimuli used in Chapter 4

Name of Video	Scene Description	Target Emotion	Clip Duration (seconds)
Silence of the Lambs	In this clip from a horror film, a detective (Clarice) knocks on the door of a man to ask questions about an ongoing kidnapping investigation, only to realize that the man is the criminal (Buffalo Bill) that she's been searching for. In a suspenseful scene, the man escapes and hides within his own house, while Clarice hears cries of help from his victim. Clarice searches through the eerie house knowing Buffalo Bill could be waiting for her around any corner. The clip ends as the suspenseful music intensifies and Clarice has a frantic look of terror on her face as she searches through a dark hallway, gun withdrawn.	Fear	215
The Shining	In this clip from a horror film, a small boy named Danny plays by himself in a hallway and hears an unexpected sound in a nearby room. As he slowly inches toward the door of the room amidst suspenseful music, he asks "Mom, are you in there?" before the clip ends.	Fear	83
Cry Freedom	Based on true events, this film depicts conflict between white soldiers and black citizens of South Africa amidst Apartheid. During a peaceful protest, the white soldiers begin shooting indiscriminately towards a mob of black protesters, killing men, women and children as they run for their lives. The clip ends as a white man from the passenger seat of a car shoots and kills a young boy in the back as he was running.	Anger	161

Name of Video	Scene Description	Target Emotion	Clip Duration (seconds)
My Bodyguard	In this clip, the new kid in school, Linderman, is bullied by his enemy's (Moody) "bodyguard." Linderman tolerates several minutes of relentless provocation, and when he tries to escape on his motorbike, the bodyguard stops him, punches him giving him a bloody nose, and smashes up his bike before pushing it into a nearby pond.	Anger	235
The Champ	In this scene, Billy had just heroically won a brutal boxing match, before dying in the locker room after the fight. His young son, T.J., comes into the room and cries inconsolably while trying to wake his father up.	Sadness	139
Shawshank Redemption	In this scene, an old man named Brooks, gets released from prison on parole, and narrates his struggles adjusting to life on the outside after spending most of his life behind bars. The scene ends with him carving out the words, "Brooks was here" on a wooden beam in his halfway house before hanging himself.	Sadness	258
Pink Flamingos	In this cult classic known for its intense shock value, a drag queen named Divine, picks up the fresh feces of a dog, and plays with it in her mouth.	Disgust	34
Toe Amputation	This clip is from an educational medical video of a doctor amputating a patient's highly infected toe.	Disgust	116
"Whose Line Is It Anyway" (season? Episode?)	In this Improvisation show, Ryan and Collin perform a game called "Helping Hands," in which Ryan speaks to his lover with whom he's having an affair, while, Collin stands behind him and operates as Ryan's hands, preparing food and drinks without being able to see what he's doing. Hilarity ensues as Ryan and Collin struggle to coordinate to impress Ryan's lover.	Joy	261

Name of Video	Scene Description	Target Emotion	Clip Duration (seconds)
When Harry Met Sally	As Harry and Sally eat lunch at a diner, Harry admits that he believes all his female companions reach orgasm during sex in spite of Sally's skepticism. To make a point, Sally loudly fakes an orgasm in the diner as Harry and the rest of the restaurant patrons stare incredulously. The scene ends with an elderly woman stating, "I'll have what she's having" when a waiter approaches.	Joy	173

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Appendix D.

Questionnaires used in Chapter 4

Autism Spectrum Quotient (AQ) – Adult Version

1.	I prefer to do things with others rather than on my own	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
2.	I prefer to do things the same way over and over again.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
3.	If I try to imagine something, I find it very easy to create a picture in my mind.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
4.	I frequently get so strongly absorbed in one thing that I lose sight of other things.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
5.	I often notice small sounds when others do not.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
6.	I usually notice car number plates or similar strings of information.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
7.	Other people frequently tell me that what I've said is impolite, even though I think it is polite.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
8.	When I'm reading a story, I can easily imagine what the characters might look like.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
9.	I am fascinated by dates.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
10.	In a social group, I can easily keep track of several different people's conversations.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
11.	I find social situations easy.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
12.	I tend to notice details that others do not.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
13.	I would rather go to a library than a party.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
14.	I find making up stories easy.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
15.	I find myself drawn more strongly to people than to things.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
16.	I tend to have very strong interests which I get upset about if I can't pursue.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
17.	I enjoy social chit-chat.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree

18.	When I talk, it isn't always easy for others to get a word in edgeways.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
19.	I am fascinated by numbers.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
20.	When I'm reading a story, I find it difficult to work out the characters' intentions.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
21.	I don't particularly enjoy reading fiction.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
22.	I find it hard to make new friends.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
23.	I notice patterns in things all the time.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
24.	I would rather go to the theatre than a museum.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
25.	It does not upset me if my daily routine is disturbed.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
26.	I frequently find that I don't know how to keep a conversation going.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
27.	I find it easy to "read between the lines" when someone is talking to me.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
28.	I usually concentrate more on the whole picture, rather than the small details.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
29.	I am not very good at remembering phone numbers.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
30.	I don't usually notice small changes in a situation, or a person's appearance.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
31.	I know how to tell if someone listening to me is getting bored.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
32.	I find it easy to do more than one thing at once.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
33.	When I talk on the phone, I'm not sure when it's my turn to speak.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
34.	I enjoy doing things spontaneously.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
35.	I am often the last to understand the point of a joke.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
36.	I find it easy to work out what someone is thinking or feeling just by looking at their face.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
37.	If there is an interruption, I can switch back to what I was doing very quickly.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree

38.	I am good at social chit-chat.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
39.	People often tell me that I keep going on and on about the same thing.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
40.	When I was young, I used to enjoy playing games involving pretending with other children.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
41.	I like to collect information about categories of things (e.g. types of car, types of bird, types of train, types of plant, etc.).	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
42.	I find it difficult to imagine what it would be like to be someone else.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
43.	I like to plan any activities I participate in carefully.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
44.	I enjoy social occasions.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
45.	I find it difficult to work out people's intentions.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
46.	New situations make me anxious.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
47.	I enjoy meeting new people.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
48.	I am a good diplomat.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
49.	I am not very good at remembering people's date of birth.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
50.	I find it very easy to play games with children that involve pretending.	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree

Reversely keyed items: 1, 3, 8, 10, 11, 14, 15, 17, 24, 25, 27, 28, 29, 30, 31, 32, 34, 36, 37, 38, 40, 44, 47, 48, 49, 50

Toronto Alexithymia Scale (TAS-20)

1	2	3	4	5
Strongly Disagree	**Disagree**	**Neither**	**Agree**	**Strongly Agree**

______1. I am often confused about what emotion I am feeling.

______2. It is difficult for me to find the right words for my feelings.

______3. I have physical sensations that even doctors don't understand.

______4. I am able to describe my feelings easily.

______5. I prefer to analyze problems rather than just describe them.

______6. When I am upset, I don't know if I am sad, frightened, or angry.

______7. I find it hard to describe how I feel about people.

______8. I prefer to just let things happen rather than to understand why they turned out that way.

______9. I have feelings that I can't quite identify.

______10. Being in touch with emotions is essential.

______11. I am often puzzled by sensations in my body.

______12. People tell me to describe my feelings more.

______13. I don't know what's going on inside me.

______14. I often don't know why I am angry.

______15. I prefer talking to people about their daily activities rather than their feelings.

______16. I prefer to watch "light" entertainment shows rather than psychological dramas.

______17. It is difficult for me to reveal my innermost feelings, even to close friends.

______18. I can feel close to someone, even in moments of silence.

______19. I find examination of my feelings useful in solving personal problems.

______20. Looking for hidden meanings in movies or plays distracts from their enjoyment.

Reversely keyed items: 4, 5, 10, 18, 19

Zung Self-Rating Depression Scale (ZDS)

	A little of the time	**Some of the time**	**Good part of the time**	**Most of the time**
1. I feel down hearted and blue.				
2. Morning is when I feel the best.				
3. I have crying spells or feel like it.				
4. I have trouble sleeping at night.				
5. I eat as much as I used to.				
6. I still enjoy sex.				
7. I notice that I am losing weight.				
8. I have trouble with constipation.				
9. My heart beats faster than usual.				
10. I get tired for no reason.				
11. My mind is as clear as it used to be.				
12. I find it easy to do the things I used to.				
13. I am restless and can't keep still.				
14. I feel hopeful about the future.				
15. I am more irritable than usual.				
16. I find it easy to make decisions.				
17. I feel that I am useful and needed.				
18. My life is pretty full.				
19. I feel that others would be better off if I were dead.				
20. I still enjoy the things I used to do.				

Reversely keyed items: 2, 5, 6, 11, 12, 15, 16, 17, 18, 20