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FACIAL EXPRESSION RECOGNITION DEFICITS IN AUTISM SPECTRUM DISORDER

Zachary Friedman

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IN AUTISM SPECTRUM DISORDER

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By

Zachary Friedman

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Tammy L. Hughes, Ph.D., ABPP
Professor
Department of Counselor Education and School Psychology Duquesne University
(Committee Chair)

Laura M. Crothers, D.Ed.
Professor
Department of Counselor Education and School Psychology Duquesne University
(Committee Member)

Gibbs Y. Kanyongo, Ph.D.
Professor and Chair
Department of Educational Foundations and Leadership Duquesne University (Committee Member)

ABSTRACT

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Dissertation supervised by Tammy Hughes, Ph.D., ABPP

Autism Spectrum Disorders (ASD) are an umbrella term for lifelong neurobehavioral disorders characterized by a set of social (verbal and nonverbal) communication challenges and behaviors and restricted, repetitive behaviors. Emotions serve many functions, but primarily they help with the appraisal of stimuli and driving of responses. Emotional processing and facial recognition are integral abilities that influence the acquisition of social skills. For individuals with ASD, it is hypothesized that facial recognition deficits contribute to social communication traits. The bulk of previously conducted research has utilized static images of facial expressions. This study utilized videos of spontaneous expressions. Participants were tasked with labeling facial expression valence. Neither a participants' level of ASD severity or their age were significant predictors of facial expression valence labeling. Furthermore, neither independent variable, age or ASD severity level, had a significant impact on their overall accuracy of labeling facial expression valence. On average, videos of a happy facial expression were most correctly labeled, while sad faces on average were the most incorrectly labeled videos.

Keywords: Autism Spectrum Disorders, emotional development, facial expressions, emotion awareness, emotion expression, emotion regulation, nonverbal communication

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To my friends: Some of you don't quite understand what a dissertation is or what exactly my profession entails. Others of you have asked me incessantly for the past 5 years when I'll be done with this doctorate. If you're reading this, I'm done, so please stop asking. I love you and am forever grateful for our friendship.

Lastly, I would like to thank my family for your love and support. I truly could not and would not be in this position today if it were not for you. You motivated me to push forward,

even when things felt insurmountable. Mom, Dad, and Taryn, I love you and am forever grateful for you.

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Chapter I

Introduction

Autism Spectrum Disorder

The earliest scientific description of Autism Spectrum Disorders (ASD) can be dated to the early 1940s. Drs. Leo Kanner and Hans Asperger were the first to publish on the unique behavioral presentation they observed in what would later be known as ASD. In a landmark paper, Kanner was the first to propose the term *autistic* in reference to 11 children whom he observed to demonstrate high intellectual functioning while also having a strong desire for 'aloneness and sameness' in their immediate environment (Kanner, 1944). In 1944, Asperger published work defining *autistic psychopathy*. He had identified four boys displaying the same patterns of behavior. These behaviors included a lack of empathy, decreased ability to initiate and maintain friendships, lack of reciprocal communication abilities, intense absorption in special interests, and clumsy movements (Kanner, 1944).

Since the 1940s, autism research has increased dramatically. Currently, researchers view ASD as a neurodevelopmental disorder resulting from genetic vulnerability (Trevarthen, 2000), with a significant interaction between genes and the environment (Muhle et al., 2004). According to the Centers for Disease Control and Prevention (CDC), 1 in 150 children were diagnosed with an ASD in 2000. By 2014, the prevalence had increased to 1 in 59 children diagnosed with ASD (Baio, 2014). Prevalence rates, however, appear to be varied for numerous reasons. Investigators interested in the prevalence rates have identified regional, gender-specific, and racial factors responsible for inconsistent rates. For instance, the prevalence rate was as high as 1 in 34 in New Jersey but just 1 in 77 children in Arkansas. In 2014, boys were 4 times more likely to be diagnosed than girls (1 in 37 versus 1 in 151). White children were most likely to be diagnosed

(Baio, 2014). This gap, however, has narrowed in recent years, appearing to reflect increased awareness and screening in minority communities (Baio, 2014).

In 1998, a study was published by Dr. Andrew Wakefield, formally a physician at the Royal Free Hospital in London, that posited a causal connection between thimerosal, a preservative added to vaccines, and ASD (Wakefield, 1998). Quickly after publishing the conclusions, he and the *Lancet* retracted the article for several reasons. Despite many subsequent attempts from within the scientific community to unequivocally reject the findings by publishing new articles, the lay public – already searching for a simplistic explanation – viewed the connection as real and its removal as conspiratorial.

Since the publishing of the now infamous article, many negative outcomes have emerged. Regardless of the misinformation that can be found online, and the avoidable stigma felt by parents and children with ASD, funding committed to ASD since 1998 has increased exponentially (Interagency Autism Coordinating Committee, 2016).). From 1997 to 2014, funding for ASD research increased by more than $1 billion domestic dollars (Autism CARES Act, 2014).

The etiology of ASD is largely unknown. Genetics play an integral role in the development of the disorder (Currenti, 2010). As a product of the increase in funding for ASD-related studies, several dozen ASD-susceptibility genes were identified between 2001 and 2011 alone. These findings provided the conclusion that ASD was etiologically heterogeneous (Geschwind, 2011).

Theoretical Basis

To try to describe and quantify ASD and the diagnostic behavioral symptoms, several theories have been hypothesized. Theory of Mind is one's ability to represent the mental states of others (Baron-Cohen, 2000). People diagnosed with ASD have impairments within their Theory of Mind capabilities. This ability allows for the anticipation the intentions of the social world. Theory of mind in typical development allows for the seamless integration of the environment and subtlety in the social world. Conversely, individuals with difficulties in Theory of Mind, like those with ASD, do not evaluate social behavior holistically; rather, they perceive behavior in fragmented segments. Thus, accurate perception of social communication and behavior may be impossible for individual with ASD to achieve as development progresses.

Those advancing the Theory of Executive Dysfunction attempt to explain the restricted and stereotyped patterns of observed behaviors, interests, and activities in people with ASD. Executive functions (EF) are innate cognitive abilities that allow us to be flexible, anticipate, plan, set objectives and goals, control our impulses, and increase in functionality through typical development (Hill, 2004). For individuals with ASD, performance on measures that assess specific EFs are impaired when compared to those enjoying typical development (Hill, 2004). EFs are particularly advantageous in new situations in which we have not developed a previous plan of action. However, for individuals with ASD, deficits in EFs are most apparent in social situations that require a plan to achieve success. In social situations, an individual with ASD might not have the ability to inhibit an antisocial behavior or comment.

Theorists advancing the idea of Weak Central Coherence posit that two processes are involved: perceptual processing and conceptual processing. For individuals with ASD, perceptual processing involves a preference towards processing local information before global information. This suggests that individuals with ASD are local information processors and neurotypically-developed individuals are more global processors (Frith, 1989).

More recently through the use of brain imaging technology, it has been discerned that people with ASD had significantly less activity in almost all brain areas associated with empathy. The final theory, the theory of empathizing-systemizing, tries to explain difficulties of people with ASD in establishing communication and creating social relationships (Baron-Cohen, 2009).

Autism Spectrum Disorder Characteristics

Broadly, ASD is a lifelong neurobehavioral disorder characterized by a set of verbal and nonverbal communication deficits and behaviors. The Diagnostic and Statistical Manual of Mental Disorders – Fifth Edition (DSM-5) provides the diagnostic criteria needed to determine eligibility for an ASD diagnosis (APA, 2013). Autism Spectrum Disorder is characterized by persistent deficits in social communication and social interaction across multiple contexts, which are pervasive across a broad scope of social situations and settings. In addition, the diagnosis of ASD requires the presence of restricted, repetitive patterns of behaviors, interests, or activities.

Individuals with ASD also experience associated challenges. These challenges include sleep-related disturbances (Williams et al., 2004), executive functioning deficits (Hill, 2004; Robinson et al., 2009), and impaired Theory of Mind abilities (Baron-Cohen, 2000).

Emotions

Emotional processing and facial recognition are integral abilities that influence the acquisition of social skills (Ekman & Friesen, 1971). By correctly identifying and understanding others' facial expressions, we can become aware of others' mental states as well as their intentions. In typical development, processing of emotional facial expressions is associated with widespread neural activation encompassing a wide range of regions in the brain. The activation of different areas of the brain is dependent upon the specific emotion (Blair et al., 1999). In children with ASD, fMRI results during emotional facial processing shows atypical activation of neural networks (Ashwin et al., 2007; Critchley et al., 2000).

Researchers generally agree that by as early as two months old, neurotypical individuals develop the ability to imitate and discriminate facial expressions (Field et al., 1983; Messinger et al., 2014). By the age of six, they can identify several emotional facial expressions with relative accuracy (Izard, 1971). By adolescence, neurotypical individuals' brains continue to develop, suggesting that facial recognition abilities may not be fully realized until adulthood. As individuals enter adulthood, they have become experts in recognizing subtlety in facial expressions (Kanwisher et al., 1997; Thomas et al., 2001).

For individuals with ASD, the lifespan trajectory of facial expression recognition is less clear. Individuals with ASD are often behind their same-age peers during infancy and childhood. Little is known about childhood and early adolescence for individuals with ASD and their ability to process facial expressions (Leung et al., 2015). By adulthood, individuals with ASD can process facial expressions relatively accurately, but their full recognition potential is discrepant when compared to neurotypical individuals (Leung et al., 2015).

To try to explain this lifelong struggle to identify facial expressions, researchers have posited a few hypotheses that try to address the issue. The Mirror Neuron System is a neural network that spikes in neural activity when two environmental stimuli present themselves: when observing another human being, and when the observer then performs the same act (di Pellegrino et al., 1992). For individuals with ASD, there has been extensive research investigating the role of the MNS (Oberman & Ramachandran, 2007, 2008). The myriad of research published investigating the role of the MNS have demonstrated that mirror neurons are dysfunctional in those with ASD. Debate continues as to the exact nature of the dysfunction, whether it is a structural or functional deficit (Dapretto et al., 2006).

The next theory for the facial recognition deficit is called the *Amygdala Theory of ASD*. The amygdala is an almond-shaped brain structure widely considered the emotion center of the central nervous system. Through neuroimaging research, the amygdala shows increased activation during the experience and expression of fear, anxiety, and related states (LeDoux, 2007; Öhman, 2009). For individuals with ASD, researchers using neuroimaging have discovered consistent deficits in the activation of the amygdala and instead, varied activation in other brain structures not typically utilized for emotion-related tasks (Baron-Cohen et al., 2000; Di Martino et al., 2009). The final hypothesis posited to explain the deficit in facial expression recognition deals with a deficit in *Theory of Mind*. Theory of mind is the ability to infer the full range of cognitions (beliefs, desires, intentions, imagination, emotions, etc.) that cause action (Baron-Cohen, 2000). By not being able to correctly infer information from nonverbal communication – facial expressions – individuals with ASD struggle to communicate socially.

Significance of the Problem

Individuals with ASD experience a lifelong struggle to correctly identify nonverbal communication, most notably facial expressions. Facial expressions are often quick to present and then equally fleeting. By not correctly identifying, or even seeing altogether the facial expressions, individuals with ASD have difficulty understanding others' intentions. However, when information, like facial expressions, is presented in a way that allows individuals with ASD to understand the social cues, they can and often do exhibit interest or concern, similarly to their neurotypical peers (Blair, 1999; Jones et al., 2010; Sigman et al., 2003). By missing or misinterpreting social cues, it is nearly impossible for individuals with ASD and especially school-aged children with ASD to succeed socially. This is precisely why mental health professionals, and namely school psychologists, are uniquely positioned to address these deficits.

Schools and school psychologists have the ability to place kids with ASD into classrooms and situations that maximize their opportunity to succeed academically and socially. Teachers and individuals that interact with these children can better adapt themselves to best communicate with kids with ASD. But, above all else, understanding how children with ASD interpret facial expressions can influence every aspect of treatment planning and implementation of intervention. Accordingly, the purpose of this study was to evaluate children and adolescents' with ASDs' ability to label facial expression valence. The following research questions were addressed:

Research Question 1: Does ASD severity level and age predict accuracy of labeling facial expression valence?

> **Hypothesis 1:** It is expected that as ASD severity level and age are significant predictors of the accuracy of labeling facial expression valence.

Research Question 2: What facial expression valence is most often correctly labeled by children with ASD?

Research Question 3: What facial expression valence is most often incorrectly labeled by children with ASD?

Summary

There is a lack of definitive research investigating the ability of those with ASD to process, interpret, and label facial expressions of emotions. Social communication deficits and deficits in correctly identifying facial expressions are predominant diagnostic criteria for individuals with ASD. Without the ability to correctly identify social cues like facial expressions, it becomes nearly impossible for individuals with ASD to achieve success to their fullest potential in the social world. As such, in this study, I sought to measure the ability of children and adolescents with an ASD to label facial expression valence. By understanding the ability, mental health practitioners can better treat individuals with ASD.

Chapter II

Review of Literature

Historical Background

The earliest scientific description of autism spectrum disorders (ASD) can be dated to 1943. Leo Kanner published work on the unique behavioral presentation of individuals that (under modern diagnostic criteria) would later be diagnosed with ASD. In a landmark paper, Kanner was the first to propose the term *autistic* in reference to 11 children whom he observed demonstrated high intellectual functioning while also having a strong desire for 'aloneness and sameness' in their immediate environment (Kanner, 1944). One of Kanner's students was an Austrian psychiatrist named Hans Asperger. In 1944, Asperger published work defining *autistic psychopathy*, after identifying four boys displaying the same patterns of behavior. The behaviors included a lack of empathy, decreased ability to initiate and maintain friendships, lack of reciprocal communication abilities, intense absorption in special interests, and clumsy movements (Kanner, 1944).

Since the 1940s, autism research has increased dramatically but there is a continued need for more work to be done. Starting in the late 1990s, the scientific community began to recognize and later replicate the work done by Kanner and Asperger as the prevalence of ASD also increased tenfold (Baio, 2014). Currently, researchers view ASD as a neurodevelopmental disorder resulting from genetic vulnerability (Trevarthen, 2000), with a significant interaction between genes and the environment (Muhle, Trentacoste, & Rapin, 2004).

Prevalence of Autism Spectrum Disorder

According to the Centers for Disease Control and Prevention (CDC), 1 in 150 children were diagnosed with an ASD in 2000. In 2014, the prevalence had increased to 1 in 59 children diagnosed with ASD (Baio, 2014). Prevalence rates, however, appear to be varied for numerous reasons. Regional estimates in 2012 suggested varying rates in different states. For instance, the prevalence rate was as high as 1 in 34 in New Jersey but was just 1 in 77 children in Arkansas. In the case of New Jersey, the researchers were given better access to educational records when conducting the studies. In 2014, boys were 4 times more likely to be diagnosed than girls (1 in 37 versus 1 in 151). This is in comparison to 2012, in which boys were 4.5 times more likely to be diagnosed. This reflects improved identification processes, particularly because girls often do not fit into the stereotypical mold for diagnosis. White children were more likely to be diagnosed than were minority children. Despite this statistic, racial prevalence statistics have closed the gaps between demographic groups since 2012. This likely reflects increased awareness and screening procedures in minority communities (Baio, 2014).

Vaccines and Subsequent Myths

In 1998, a study was published by Dr. Andrew Wakefield, formally a physician at the Royal Free Hospital in London, in which he posited a causal connection between thimerosal, a preservative added to vaccines and ASD (Wakefield, 1998). Quickly after publishing his conclusions, he and the *Lancet* retracted the article for a few reasons. The study included a small sample size (n=12), the design was largely uncontrolled, and the conclusions drawn were almost predestined: both the MMR vaccine and ASD occur in early childhood (Sathyanarayana Rao & Andrade, 2011). The *Lancet* also admitted that Wakefield had failed to disclose that his research was funded by lawyers representing parents currently in litigation with vaccine manufacturers.

Despite the retraction, the lay public -- already searching for a simplistic explanation -- viewed the connection as real and its removal as conspiratorial. As a result of its publishing, many parents decided to not vaccinate their children, ultimately exposing them to additional, previously avoided risks of preventable diseases. In response to this infamous article, many peer-reviewed articles were published in rigorous and respected journals by highly competent researchers refuting its results. The largest and most often cited was a meta-analysis published in *Vaccine* by Taylor, Swerdfeger, & Eslick (2014). Through an exhaustive evidence-based meta-analysis of case-controlled and cohort studies, the authors unequivocally stated that vaccines were not associated with the development of ASD (Taylor et al., 2014).

While this was a huge accomplishment within the scientific community, myths about the causes and treatments for ASD persisted within the public. The broader issue regarding the fraudulent and non-evidence-based misinformation found online contributed more to the stigma surrounding ASD and developmental disorders in general. Unfounded causes of ASD included vaccines, relative finger length, and certain parenting styles (Salzberg, 2019). Treatment myths included stem cells, a gluten free diet, and a miracle mineral solution (Salzberg, 2019). What has not been questioned was that the exposure to stigma and discrimination could adversely effect mood and emotional wellbeing, as well as reduce access to health care (Earnshaw & Quinn, 2012; Smith el al., 2011).

Research outcomes have been published on parents of children with ASD feeling A) stigmatized (Gray, 1993, 2002), B) the negative impact of a lack of knowledge about ASD (Broady et al., 2015), C) feeling stigmatized and victimized by their peers during social encounters (Shtayemman, 2009). There is also extensive research that linked mental illness, stigma, and treatment outcomes (Angermayer & Dietrich, 2006; Corrigan, 2002; Ellison et al., 2013). Research findings have suggested that mental illness stigma, both public stigma and self-stigma, have lead to increased emotional stress reactions (e.g., social anxiety, low self-esteem, hopelessness). The increased stress associated with stigma can increase risk for a few prolonged physical (high blood pressure, heart disease, obesity) and emotional symptoms (depression, anxiety, etc.).

Funding Committed to Autism Spectrum Disorders Research

While the damage inflicted both directly and indirectly from Wakefield's redacted article might never truly be quantified, there was one irrefutable positive outcome. The layperson was interested and talking about ASD more than ever before. In the year 2000, just 2 short years after the publication of the Wakefield article, the Interagency Autism Coordinating Committee (IACC) was formed under the Health and Human Services (HHS) branch of the government (Interagency Autism Coordinating Committee, 2016). The primary objective of the IACC is to monitor ASD-based research and to ensure efforts and funds are not being used for duplicative purposes. As a result of the increased public interest, money began to flow into academia for the sole purpose of investigating ASD. From 1997 to 2001, ASD research funding grew from $22 million to $56 million. It was difficult to find published research directly linking Wakefield's claims and the increase in funding for ASD based research, but it was highly unlikely that the two were mutually exclusive.

Since the IACC's first report in 2001, research funding has steadily and consistently increased. In 2012, the Office of Autism Research Coordination (OARC) and the IACC released a report on ASD funding not just from the National Institutes of Health (NIH), but also from the CDC, the Environmental Protection Agency (EPA), and the National Science Foundation (NSF), as well as private organizations like the Simons Foundation and Autism Speaks (Interagency Autism Coordinating Committee, 2016). In 2012, approximately $331 million was committed to ASD-related research. For reference, in the same year, $271 million was committed to AIDS research, $234 million to Leukemia research, and $315 million to lung cancer research (National

Cancer Institute, 2012). National Institute of Mental Health data reveals that in 2019, $296 million was spent on ASD research while only $58 million was committed to Attention-Deficit Hyperactivity Disorder (ADHD) research (National Institute of Mental Health, 2019).

Etiology

Simply, the etiology of ASD is largely unknown, populated by unresearched theories and plausible yet weak correlational studies. However, what has been agreed upon by researchers is the role that genetics play in the process (Currenti, 2010). From 2001-2011, several dozen ASD susceptibility genes had been identified which collectively accounted for 10-20% of ASD cases. These findings provided the conclusion that ASD was etiologically heterogeneous (Geschwind, 2011).

More specifically, several etiological factors have been proposed, most notably the extreme male brain theory of autism, a dysregulation of axonal growth, and differences in gut biomes for individuals with ASD. For individuals with ASD, researchers have demonstrated gender-related neurological differences. Simon Baron-Cohen, a world renowned researcher on ASD, along with his colleagues, believe that the human brain can be classified and quantified using two abilities, empathic thinking (E) and systematic thinking (S). Empathic thinking, or the empathy quotient (EQ), measures one's empathy, or the ability to feel an appropriate emotion in response to another's emotion and to then understand the others' emotion. Alternatively, systematic thinking, or systemizing quotient (SQ) refers to one's tendency to put things into order. By measuring the differences between the two, Baron-Cohen generated five different brain profiles.

> "(1) Individuals in whom empathizing is more developed than systemizing. For shorthand, E > S (or Type E). This is what we will call the 'female brain'. (2) Individuals

in whom systemizing is more developed than empathizing. For shorthand, S > E (or Type S). This is what we will call the 'male brain'. (3) Individuals in whom systemizing and empathizing are both equally developed. For shorthand, S = E. This is what we will call the 'balanced brain'(or Type B). (4) Individuals with the extreme of the male brain, for shorthand, S >> E. In their case, systemizing is hyper-developed whereas empathizing is hypodeveloped. That is, they might be talented systemisers but at the same time they can be 'mindblind'. In this article, we look at individuals on the autistic spectrum to see if they fit the profile of being an extreme of the male brain. (5) Finally, we postulate the existence of the extreme of the female brain. For shorthand, E >> S. These people would have hyper-developed empathizing skills, but their systemizing would be hypo-developed: they are 'system-blind'(Baron-Cohen, 2002, p. 248)."

Researchers have found that nearly 65% of individuals with ASD fall under the extreme type S. In addition to this, the extreme male brain theory of ASD was coined as such because Baron-Cohen also discovered that twice as many males with ASD than females with ASD were type S (Baron-Cohen, 2002).

Another etiological factor of recent research interest has been the differences in gut biome chemistry among individuals with ASD. The human gut is comprised of a complex microbial community, or microbiota, that contribute to the breakdown and subsequent supply of energy to the host. The microbiota also regulate host cell circuits with consequent effects on cancer risk and inflammatory tone, as well as impacting the host's immune system, and protecting against pathogens. More recently, researchers have begun to discover that the microbiota has a much more widespread impact on the host. In fact, some believe that the microbiota may modulate brain activity and behavior (Louis, 2012). A subset of individuals with

ASD in research settings have reported gastrointestinal (GI) symptoms. Changes in microbiota composition in individuals with ASD have been identified, ultimately lending some initial credence to the microbiota hypothesis as an etiological factor for ASD (Louis, 2012).

Most recently with the vastly improved neuroimaging techniques, a new theory concerning the etiology of ASD has emerged: abnormal brain connectivity and more specifically, the dysregulation of axonal growth. In the first few years of life, structural studies of brain development have indicated that a large subset of individuals with ASD experience dramatic overgrowth in the frontal lobe. Despite a tendency for the brain to normalize by adulthood, these early phases of brain development can lead to dysregulated synapses between the frontal lobe and other brain regions and structures (McFadden & Minshew, 2013). This notion is most supported through research investigating executive functioning, which has accounted for a predominant deficit highlighted by the diagnostic criteria for ASD. Specifically, executive functions are regulated by the frontal lobe. For individuals with ASD, their planning, mental flexibility, behavioral inhibition, and generativity are deficient (Hill, 2004). Dysregulated axonal growth has steadily gained traction as an important etiological factor to consider for ASD.

Several risk factors for ASD have been suggested. Broadly, there are four predominant areas of investigation: 1) prenatal factors, 2) perinatal factors, 3) maternal diet, and 4) maternal lifestyle factors. Advanced maternal age (>40 years), advanced paternal age (>50), and short inter-pregnancy intervals (<24 months between births) have been independently associated with increased risk for ASD (Idring et al., 2014; Lyall et al., 2017; Mandy & Lai, 2017). Other factors that have been associated with mildly increased risk of ASD include non-specific, non-optimal factors during pregnancy (maternal metabolic conditions, significant weight gain, hypertension) and more specific factors like maternal admission to the hospital due to a bacterial or viral infection or familial history of autoimmune disease (Lyall et al., 2014).

Theoretical Basis

To try to describe and quantify ASD and the diagnostic behavioral symptoms, several theories have been hypothesized. The most recognized theories are: a) the Theory of Mind, b) the Theory of Executive Dysfunction, c) the Theory of Weak Central Coherence, and d) the Theory of Empathizing – Systemizing.

Theory of Mind

Theory of Mind is one's ability to represent the mental states of others (Baron-Cohen, 2000). People diagnosed with ASD have this capacity impaired. This ability allows us to anticipate the intentions of the social world. Theory of mind in typical development allows for the seamless integration of the environment and subtlety in the social world. Conversely, individuals with difficulties in Theory of Mind, like those with ASD, will break down social behavior into smaller pieces. This can become tedious and near impossible as the demands increase as development progresses.

Theory of Executive Dysfunction

The Theory of Executive Dysfunction attempts to explain the restricted and stereotyped patterns of observed behaviors, interests, and activities in people with ASD. The diagnostic criteria for ASD will be discussed later on in this chapter, but the salient feature to understand at this point is a strong tendency towards restricted and stereotyped behaviors, interests, and activities. Executive functions (EF) are innate cognitive skills through typical development allow us to be flexible, anticipate, plan, set objectives and goals, and control our impulses (Hill, 2004). They are particularly advantageous in new situations where we don't have a previous plan of action or existing schema. For individuals with ASD, performance on measures that assess specific EFs are impaired when compared to typical development (Hill, 2004).

Theory of Weak Central Coherence

Individuals with ASD have difficulty processing global environmental information, instead focusing their attention on small details (APA, 2013). The Theory of Weak Central Coherence posits two parts are involved: perceptual processing and conceptual processing. For individuals with ASD, perceptual processing involves a preference towards processing local information before global information. In other words, people with ASD focus on specific details of images or objects before focusing on its entirety. Conceptual processing involves combining previously acquired knowledge and contextual information. People with ASD tend to fail to combine the two (Frith, 1989). This suggests that individuals with ASD are local information processors and neurotypical-developed individuals are more global processors.

Theory of Empathizing-Systemizing

More recently, with the use of brain imaging technology, people with ASD were found to have significantly less activity in almost all brain areas associated with empathy. This does not, however, mean that those with ASD cannot learn empathy but it will not be an intuitive or primitive process. Therefore, those espousing the theory of empathizing-systemizing try to explain difficulties of people with ASD establishing communication and creating social relationships (Baron-Cohen, 2009).

Autism Spectrum Disorder Characteristics

Broadly, ASD is a lifelong neurobehavioral disorder characterized by a set of verbal and nonverbal communication deficits and behaviors. The Diagnostic and Statistical Manual of Mental Disorders – Fifth Edition (DSM-5) provides the diagnostic criteria needed to determine eligibility for an ASD diagnosis (APA, 2013). Autism Spectrum Disorder is characterized by persistent deficits in social communication and social interaction across multiple contexts, which are pervasive across a broad scope of social situations and settings. In addition, the diagnosis of ASD requires the presence of restricted, repetitive patterns of behaviors, interests, or activities.

Social Communication Deficits

Individuals who are being considered for a diagnosis of ASD must present with deficits in social-emotional reciprocity. This can be observed on a range of severities from abnormal social approach and a failure to engage in normal back-and-forth conversation to a reduced sharing of interests, emotions, and a total lack of social interaction (APA, 2013; Mash & Barkley, 2014).

Verbal communication deficits include a lack of responsive social smile, failure to share enjoyment, excitement, or achievements with others, reduced sharing of interests, and lack of initiation of social interactions. In addition to the verbal communicative deficits, there are also deficits in nonverbal communication. These may include lack of eye contact, misunderstanding of affect, or lack of coordinated non-verbal communication (e.g., an inability to coordinate eye contact with gestures). These deficits also include a varied yet reliable deficit in correctly identifying facial expressions (APA, 2013; Mash & Barkley, 2014).

Individuals with ASD also have deficits in developing and maintaining relationships. The verbal and non-verbal communication deficits contribute to challenges with reciprocal communication that are crucial in initiating and maintaining relationships. There is a general lack of interest in others and difficulty adjusting behavior to suit specific social contexts (APA, 2013; Mash & Barkley, 2014).

Restricted, Repetitive Behaviors

In addition to the social communication deficits, individuals with ASD also demonstrate a pattern of restricted and repetitive behaviors, interests, or activities. These symptoms can manifest as stereotyped or repetitive speech, motor movements, and/or use of objects. Stereotyped or repetitive speech could be pedantic speech, echolalia, use of "jargon" or pronoun reversal. Stereotyped or repetitive motor movements may present in various behavioral manifestations, for example, clapping, flapping, abnormalities of posture, or unusual face grimacing. Stereotyped or repetitive use of objects could be nonfunctional play with objects like waving sticks, lining up toys, and/or repetitively opening/closing doors or turning on/off lights (APA, 2013; Mash & Barkley, 2014).

Restricted and repetitive behaviors also include an excessive adherence to routines, ritualized patterns of verbal or nonverbal behavior, an excessive resistance to change, and/or a rigid pattern of thinking. Adherence to routine involves an insistence on rigidly following a specific routine or having unusual routines. Ritualized patterns of verbal and nonverbal behaviors include repetitive questioning about a particular topic, verbal rituals, and/or compulsions. Excessive resistance to change involves difficulties with transitions in routines or schedules and/or an overreaction to trivial changes. Rigid thinking manifests difficulty understanding humor, nonliteral aspects of speech like irony or implied meaning, and/or excessively rigid, inflexible, or rule-bound in behavior or thought (APA, 2013; Mash & Barkley, 2014).

Individuals with ASD might have highly restricted and fixated interests that are abnormal in intensity and focus. This may be observed as, but not limited to obsessions, preoccupations, narrow range of interests, and/or unusual fears (APA, 2013; Mash & Barkley, 2014).

Finally, individuals with ASD may have hyper- or hypo-reactivity to sensory input or unusual interest in sensory aspects of their immediate environment. For example, this may be observed as a preoccupation with specific textures or touch, unusual visual exploration like unusual squinting of eyes or looking out of the corner of the eyes. This is also observed as unusual sensory exploration with objects, sounds, smells, or tastes (APA, 2013; Mash & Barkley, 2014).

When considering if an individual meets the diagnostic criteria for a formal diagnosis of ASD, practitioners are supposed to make a determination regarding their severity level. Per the most recent update of the DSM-5, practitioners can decide, typically based on multiple data points, if the individual falls in the Level 1 "requiring support", Level 2 "requiring substantial support", or the most severe level, Level 3 "requiring very substantial support" (APA, 2013). Previous iterations of the DSM included various disorders that fell within the autism *spectrum* but were not considered ASD. In the most recent update, however, the newly added ASD severity level qualifiers attempted to quantify the various challenges existing between all individuals on the same autism spectrum (Weitlauf et al., 2014).

Associated Challenges

Sleep-related disturbances

Sleep-related disturbances are a common associated challenge of children diagnosed with ASD. Sleep disorders in children are not a unitary clinical problem and are commonly classified into two major categories. Dyssomnias include disorders of initiating or maintaining sleep. Parasomnias are disorders that disrupt sleep after it has been initiated (Liu et al., 2006). Researchers have found estimates between 54 and 86% of children with ASD reported having at least one type of sleep disturbance. This is in comparison to 12% to 76% of neurotypical-developed children reporting some form of a sleep disturbance (Fricke-Oekermann, et al., 2007). These disturbances can include but are not limited to difficulties falling asleep, experiencing restless sleep, an unwillingness to fall asleep in their own bed, frequent awakenings, difficulty arousing, enuresis, disoriented waking, daytime mouth breathing, or excessive daytime sleepiness (Williams et al., 2004).

Theories to explain the sleep disturbances in children with ASD are only conjecture at this point. Some researchers have suggested that perhaps abnormalities in the hypothalamic – pituitary – adrenal (HPA axis) was dysregulating circadian rhythms and alterations in hormone/neurotransmitter (melatonin/serotonin) production (Williams et al., 2004). Despite these unknowns, without proper sleep and the associated restorative aspects for our bodies, links have been made to several negative consequences. For instance, some research studies have found links between sleep disturbances and impaired vigilance, learning, memory, increase aggression, and increased irritability (Gozal, 1998; Horne, 1988; Quine, 1991).

Executive functioning deficits

Executive functions (EF) are a set of complex cognitive constructs encompassing processes underlying controlled and goal-directed responses to novel or difficult situations. More specifically, EF are necessary in situations that involve: 1) planning and decision-making, 2) error correction or troubleshooting, 3) initiation of novel sequences of actions, 4) danger or technical difficulty, or 5) the need to overcome a strong habitual response (Robinson et al., 2009). Executive dysfunction, specific to ASD, has been widely investigated. In a review of the ASD literature, difficulties have been reported in executive domains of planning, mental flexibility, inhibition, generativity, and self-monitoring (Hill, 2004).

Planning is an executive function broadly defined as a skill that requires constant monitoring, evaluation, and updating of actions (Hill, 2004). The Tower of London (ToL) task has often been used to assess planning and problem-solving skills. The task requires participants to move pieces from a prearranged sequence to match a goal determined by the examiner. When compared to age and/or IQ matched controls, children with low functioning ASD have been reported to be significantly impaired on the ToL (Robinson et al., 2009).

Mental flexibility refers to the ability to shift to a different thought or action response to situational changes. A classic neuropsychological test of mental flexibility is the Wisconsin Card Sorting Task (WCST). This requires participants to sort cards according to one of three possible rules: by color, by shape, or by count. Executive dysfunction on this task is typically seen with individuals with ASD. Researchers have indicated that profiles of individuals with ASD on the WCST have shown highly perseverative scores (Robinson et al., 2009).

Behavioral response inhibition is the ability to suppress irrelevant or interfering information or impulses (Robinson et al., 2009). Inhibition is measured using go/no go tasks like the Stroop Task. Unlike planning and mental flexibility, inhibition is unimpaired in children and adolescents diagnosed with ASD. Impaired response inhibition has, however, been reported on the Windows Task, and variations of this task for children with ASD (Biro & Russell, 2001; Hughes & Russell, 1993; Russell et al., 1991; Russell et al., 2003). This task requires the child to inhibit response of pointing to the box that contains a desired stimulus and instead point to an empty box beside it. Poor performance on these tasks indicates a difficulty inhibiting pre-potent responding (Robinson et al., 2009).

Generativity is the ability to generate novel ideas and behaviors spontaneously (Turner, 1997). To assess generativity, verbal fluency measures are typically used. The participant is asked to produce as many words as possible within a specified time limit in response to a phonetic (start with the same letter) or semantic (category) prompt. Some researchers have suggested that individuals with ASD show impaired performance on these measures. Other researchers believe that a deficit in verbal fluency or generativity is related more to impaired performance on response inhibition tasks (Robinson et al., 2009).

Self-monitoring is the ability to monitor one's own thoughts and actions (Hill, 2004). Most often, impairments in self-monitoring have been reported in a post hoc basis, for example error correction, avoidance, and memory for actions (Hughes, 1996; Russell & Jarrold, 1998). Monitoring one's verbal and behavioral output is required on the previously mentioned measures to assess executive functioning. Therefore, self-monitoring deficits may contribute to performance with regards to other executive functions, but this has not yet been reported for individuals with ASD (Robinson et al., 2009).

Executive functions are strongly intertwined with basic human development. As the social and emotional world matures around us, the demands require gradually evolving and appropriate responses, which are in part modulated by EF. Researchers have found a direct link between age and increasing EF impairments in children with ASD. Specifically, parents of older children with ASD reported greater problems on domains of task and self-initiation, working memory, and organization of materials than were reported for younger children with ASD. Regarding performance on metacognition task, there was a widening gap between the normative sample and the sample with ASD as they aged (Rosenthal et al., 2013).

Theory of mind

In the DSM-V, Theory of Mind (ToM) is categorized as an associated challenge of ASD (APA, 2013). Simply, theory of mind is the process of attributing mental states to oneself and to others and to understand that others have beliefs that are different from one's own (Baron-Cohen, 2000). There are several hypotheses used by researchers to posit reasons as to why emotional processing is so difficult for individuals with ASD. Many researchers believe that deficits in ToM are the driving force behind this impairment (Baron-Cohen, 2000). Baron-Cohen was the first to hypothesize the importance of the ToM deficits. Between 1989 and 1997, he published numerous papers citing consistent impairments on tests designed to assess ToM in children with ASD. All in all, he used 20 tests to measure ToM in children with ASD. He found consistent and strong evidence in support of a ToM deficit.

A classic example of one of the tests used by Baron-Cohen was the mental – physical distinction (Baron-Cohen, 2001b). Many consider this distinction to be a cornerstone of ToM and one that is not explicitly taught by parents or caregivers. The child listens to a story in which one character is having a mental experience thinking about a dog while a second character is having a physical experience like holding a dog. The experimenter then asks the subject to judge which operations the two characters can perform (e.g., Which character can pet the dog?). In typical development, 3 to 4-year-old children can easily make these judgments. However, children with ASD also aged 3 to 4 years old were significantly impaired in making such judgments (Baron-Cohen, 2001b).

Emotions

While the basic definition of an emotion is not universally agreed upon, Keltner and Gross (1999) put forth the following: emotions are, "episodic, relatively short-term, biologically-based patterns of perception, experience, physiology, action, and communication that occur in response to specific physical and social challenges and opportunities" (p. 468). The importance of this definition is in its acknowledgement of the functionality of emotions. Emotions allow us to appraise experiences, both social and personal, and prepare to respond appropriately (Cole et al., 2004). To determine the function of emotions, scientists have studied the impact that emotional deficits cause as well as the benefits of emotional intelligence.

Emotional deficits can be further reduced to two main areas of study: 1) not expressing emotions in emotionally arousing situations and 2) not understanding emotions expressed by others. When individuals do not express their emotions in typically arousing situations, it can be for a few reasons and consequently can lead to maladaptive interpersonal social functioning. An example of this is depression. Depression, like its name, depresses some emotions, thoughts, and feelings of the individual. While the experience of depression is unique to the individual, often, social situations that once brought enjoyment to a person's life are not experienced the same way or avoided all together.

Emotions can be presented in a myriad of ways but are often categorized as verbal and nonverbal. Nonverbal displays of emotions can be gazes, hand gestures, body postures, and facial expressions. Extensive research has been conducted on negative outcomes for misinterpreting or missing altogether facial expressions. Impairments in correctly identifying facial expressions have been associated with antisocial behavior (Fairchild et al., 2009; Marsh & Blair, 2008). Blair (2005) suggests that people who have an inability to accurately identify signals of distress (such as fear or sadness) were more likely to engage in aggressive or harmful behavior, likely due to a lack of empathy for the distress. Emotional deficits can also lead to ineffective behavior regulation (Bechara et al., 2000), and poor decision making (Hinson et al., 2003).

In contrast, emotional intelligence is the capacity to pay attention to and understand one's own emotions and those of others, and to use that information to inform behavior and decision making (Salovey & Mayer, 1990). High emotional intelligence has been shown to positively impact several significant domains of life (Mayer et al., 2008). Individuals high in emotional intelligence are less likely to engage in antisocial and violent behavior, less likely to abuse drugs and alcohol (Brackett et al., 2004), experience successful relationships, be judged as interpersonally sensitive (Brackett et al., 2006; Lopes et al., 2003), and be successful in organizational settings (Rosete, 2007).

Emotions are a way of interacting with the environment. Without emotional intelligence, one would have profound difficulties paying attention to and understanding the intentions and behaviors of others. These dyadic exchange structures teach and later dictate social and emotional communication. Children with ASD have deficits in language development as well as difficulties engaging in this exchange structure. These deficits often lead to severe handicaps in adjusting to the social world (Shirk & Russell, 1996, p. 231). Lacking high emotional capacity speaks mostly to the primary diagnostic criteria for ASD. Without the explicit ability to make causal connections between emotions and behaviors in the immediate environment, achieving success in the social world can become an exponentially more difficult task for individuals with ASD.

Facial expressions of emotions serve a multitude of purposes, both for the person and for observers. Facial expressions attract attention from others as well as impart information about the emotional state of the expressor. Processing social information allows observers to make decisions and behave in a way that is beneficial for themselves. Facial expressions also serve to communicate to others, even when the physical representation is not possible, like over text. Instead, more and more people utilize emojis in electronic communication to convey meaning and reduce confusion. Different facial expressions, both physical and electronic forms like emojis, provide the observer with unique information. By processing that information accurately, the observer has many choices of responding. However, when the information conveyed through facial expressions is processed inaccurately, or even not at all, the observer is unable to respond appropriately (Niedenthal & Ric, 2017).

Development of Facial Recognition Processing

The development of facial recognition processing is a lifelong endeavor. From the moment of birth, infants are exposed to a variety of stimuli, each with its own unique emotional value, like a caregiver's voice or a smiling face. Emotional processing and facial recognition are integral abilities that influence the acquisition of social skills (Ekman & Friesen, 1971). By correctly identifying and understanding others' facial expressions, we can become aware of others' mental states as well as their intentions. Emotions, both the display of and interpretation in others leads to a physiological reaction. For instance, before humans are capable of verbal communication, it is through facial expressions (nonverbal communication) that infants learn the appropriate reactions to initially ambiguous stimuli. If, for instance, the caretaker has a fearful reaction to the baby when they approach a hot stove or electrical outlet, the toddler (assuming typical development) will likely have an innate fearful physiological reaction (Askew & Field, 2007; Hertenstein & Campos, 2004). Campos and colleagues (2003) referred to facial expressions of emotion as behavior regulators because they function as rewards (Matthews & Wells, 1999) and punishments (Blair, 1995) which serve to increase or decrease behavior as in operant conditioning (Blair, 2003; Gerull & Rappe, 2002; Mumme et al., 1996).

In typical development, processing of emotional facial expressions is associated with widespread neural activation encompassing the limbic, prefrontal, temporal, temporoparietal, and visual regions of the brain. The activation of different areas of the brain is dependent upon the specific emotion (Blair et al., 1999). In children with ASD, fMRI results during emotional facial processing shows atypical activation of brain networks, which includes reduced activation in the amygdala and orbitofrontal areas as well as increased activity in the left superior temporal gyrus (Ashwin et al., 2007; Critchley et al., 2000).

Infancy

The earliest stages of life are characterized by close caregiver and infant interaction. As such, this relationship serves as a prototype for social relationships throughout life (Messinger et al., 2014). Predictably, these early relationships are characterized by nonverbal emotional communication. However, these are the infant's first experiences of feeling with another and can be considered the earliest underpinnings of lifespan emotional contagion and rapport. By as early as two months, infants can accurately mimic and reproduce a caregiver's facial expression (Messinger et al., 2014). Full-term newborns can discriminate and imitate facial expressions shortly after birth (Field et al., 1983).

Through examining these interactions in infants as early as two months of age, Messinger and colleagues demonstrated that between three and nine months of age, children become increasingly responsive to their interactive partners. By utilizing the strange situation procedure pioneered by Mary Ainsworth (Ainsworth & Bell, 1970), infants have influence on their caregivers just as reliably as caregivers have on the infants (Messinger et al., 2014). Behavioral data suggests that by seven to eight months of age, infants can categorize some emotions (Caron et al., 1982; Nelson & Dolgin, 1985; Nelson et al., 1979; Nelson et al., 1997). By 12-18 months, behavioral reactions by the infant to a person expressing joy or anger appear to influence the child's behavior (Batty & Taylor, 2006).

Data to support commonalities or differences between typically developing children and children with ASD is variable and limited. This is due in large part to the timing of reliable diagnosis of ASD (Leung et al., 2015).

Childhood

Researchers suggest that by the age of six, typically developing children can identify several emotional facial expressions with relative accuracy (Izard, 1971). MacDonald, Kirkpatrick, and Sullivan (1996) published a study assessing the emotional identification skills of children between the age of three and six. They found that the children's performance increased with age, suggesting that accurate facial expression identification skills increase with maturity. During the preschool and early primary school years, noticeable and measurable strides in the ability to correctly recognize and subsequently label various emotional facial expressions have been observed (Camras & Allison, 1985: Harrigan, 1984; Tremblay et al., 2001).

While much research exists regarding the typical child's development of facial recognition processing in early childhood, few studies have investigated the ability to recognize emotions from facial expressions during late childhood. Of these studies, the findings have been inconsistent (Mancini et al., 2013). Mancini and colleagues (2013) assessed the ability of children between the ages of eight and eleven to choose between the six basic universal emotions. These six are happy, sad, disgust, anger, fear, and surprise. Consistent with research on early childhood facial recognition, recognition accuracy increased with age, except for the recognition of happy expressions. Instead, the largest age-related increases were for neutral and sad faces.

For individuals with ASD, little is known about the developmental trajectory of facial emotion recognition processing during childhood. The early school years can become a particularly challenging place for children with ASD. Increasing task demands because of increased language capabilities results in more complex social and emotional interactions with the immediate environment (Taylor et al., 2015). Social and emotional communication becomes subtler and more complex. Despite little evidence for universal deficits during childhood for children with ASD, researchers believe that the problems evidenced during adolescence can be traced directly back to difficulties during childhood (Leung et al., 2015).

Adolescence

Neurodevelopmental studies propose that the brain areas involved in facial expression processing continue structural development throughout late childhood and early adolescence (Kanwisher et al., 1997; Thomas et al., 2001). Furthermore, this suggests that emotional facial recognition abilities may not reach full maturity until adulthood (Thomas et al., 2007).

By adolescence, it is believed that impairments in facial processing in combination with possible deficits deriving reward and punishment for facial expressions may play a part in emotional expression processing for adolescents with ASD (Leung, et al., 2015). Adolescence is typically a time of hormonal flux. As a result, there are many factors that contribute to the development of facial emotion recognition during adolescence. These factors can include age and gender. Anger and disgust are better recognized by respondents with ASD classified as late-puberty when compared to individuals with ASD classified in mid-puberty (Lawrence, Campbell, & Skuse, 2015). Sensitivity to anger also increased significantly between adolescence and adulthood.

Adulthood

During early adolescence and adulthood, individuals enter the puberty phase of development. Bodies develop on a physical level while also maturing on a chemical level. There are measurable hormonal changes that effect males and females differently. As such, this can be a crucial time for studying the development of facial expression processing. By adulthood, typically developing individuals are more sensitive to subtle changes in emotional and facial expressions (Leung et al., 2015).

Considering the lifespan

Across the lifespan, facial recognition processing development is rapid during infancy and improves with age during the preschool years. The development trajectory from late childhood to adulthood is less clear. Happiness is the first emotion that can be accurately identified in both typically developing individuals and individuals with ASD. This commonality may be a result of how frequently happiness is displayed and encountered (Farran et al., 2011). It is known, however, that adults with ASD tend to continue to experience difficulties with emotional processing, especially when the expression of emotion is brief or subtle (Begeer et al., 2006).

In both typical development and development with ASD, the recognition of emotional facial expressions reliably improves with age. The full recognition potential, though, is discrepant between typical individuals and individuals with ASD (Brewer et al., 2022). To combat this difference, individuals with ASD often develop alternative approaches to improve their performance. Through the analysis of fMRI data, individuals with ASD display an atypical brain activation within the mirror neuron system (Leung et al., 2015).

Differences in the Recognition and Perception of Emotions

Emotion perception is the process of recognizing the meaning underlying the expressions of emotions of others (Psychology of Emotion, 2006). In typical development, theorists have posited that embodied simulation explains the complex process of emotion perception.

According to the theory, people use their own brain and motor emotion system to simulate the expressions of others, which in turn gives them immediate access to the emotions underlying the perceived expression of emotion. The simulation utilizes areas of the brain typically involved in the production of the perceived facial expression and sometimes involves the physical contraction of the facial muscles involved in the facial expression (Niedenthal et al., 2010; Wood et al., 2016). This theory combines three aspects related to brain structures and functions, mirror neurons, the amygdala, and ToM. In typical development, utilizing and understanding these aspects of cognition are unconscious and seamless. However, each has been separately hypothesized to explain the emotional deficits individuals with ASD experience.

Hypotheses

Mirror neuron deficit

In the early 1990s, a group of Italian physiologists discovered a special class of motor neurons in the frontal and parietal cortex of macaque monkeys. The neurons, aptly named mirror neurons, fired during two specific times: 1) during production (e.g., the monkey grasps a peanut) and 2) during perception (the monkey observes experimenter grasping the peanut) of an action (di Pellegrino et al., 1992). This was later considered the brain's way of using a single system to achieve two different things: act upon the environment and understand other's goals and actions (Gallese et al., 1996). In typical development, individuals with intact mirror neuron systems (MNS) have overlapping and more widespread brain activation during either emotion experience and emotion perception, or emotion expression and perception, ultimately finding a role of the MNS in emotion recognition.

For individuals with ASD, there has been extensive research investigating the role of the MNS (Oberman & Ramachandran, 2007, 2008). Evidence from electroencephalographic (EEG;

Oberman et al., 2005), electromyography (EMG; McIntosh et al., 2006), transcranial magnetic stimulation (TMS; Perkins et al., 2010), and functional magnetic resonance imaging (fMRI; Rizzolatti & Fabbri-Destro, 2010) studies have demonstrated that mirror neurons are dysfunctional in those with ASD (Dapretto et al., 2006). Debate continues as to the exact nature of the dysfunction, whether it is a structural or functional deficit.

Amygdala theory of ASD

The amygdala is an almond-shaped brain structure that is widely considered the emotion center of the central nervous system (Psychology of Emotion, 2006). Through neuroimaging research, the amygdala shows increased activation during the experience and expression of fear, anxiety, and related states (LeDoux, 2007; Öhman, 2009). The amygdala is not the only structure involved in the perception and production of emotion but is the first responder to environmental stimuli and is highly interconnected to other brain areas responsible for processing visual, auditory, somatosensory, olfactory, and taste stimuli (LeDoux, 2007). For typically developing and developed individuals, fMRI research shows consistent activation of the amygdala for emotion-based recognition tasks (Psychology of Emotion, 2006).

For individuals with ASD, neuroimaging studies have found greater activation in other brain structures not utilized for processing emotions by typically developing individuals. Specifically, researchers have discovered consistent deficits in the activation of the amygdala and instead varied activation in other brain structures not typically utilized for emotion-related tasks (Baron-Cohen et al., 2000; Di Martino et al., 2009). Recently, Shen and colleagues (2016) have posited that the functional connectivity of afferent and efferent neurons of the amygdala is disrupted in preschool-aged children with ASD. These researchers found significantly weaker connectivity between the amygdala and several brain regions involved in social communication and repetitive behaviors.

Theory of mind

Theory of mind is hypothesized to be a pre-requisite to empathy (Baron-Cohen, 1995). Theory of mind is the ability to infer the full range of cognitions (beliefs, desires, intentions, imagination, emotions, etc.) that cause action (Baron-Cohen, 2000). Having a theory of mind is having the capacity of reflection of self and others' cognitions. In typical development, theory of mind abilities allow for the possible prediction of another's mental state. Empathy is a defining feature of human relationships. It stops one from doing things that would hurt another person's feelings or inflicting pain on another being.

Like theory of mind, empathy is the way you tune into someone else's world while setting aside your own. Lacking empathy is commonly seen in behavioral terms as being cold, lacking joy, and closemindedness. These three attributes are also included in the diagnostic criteria in the ASD section of the DSM-5 (APA, 2013). Consistent research has demonstrated deficits in ToM measures for individuals with ASD.

Gaps in the Literature

Within the field of ASD and specifically, the recognition of facial expressions in individuals with ASD, a meta-analysis published by Uljarevic and Hamilton (2013) investigated 48 articles in which a total of 980 participants with ASD were assessed in their ability to recognize emotions. Uljarevic and Hamilton (2013)'s work demonstrated an important through line over 25 years of prior research: the importance of continuing to measure emotion recognition deficits in ASD. As with any scientific or research endeavor there are always unknowns and new directions for researchers to investigate. This meta-analysis represented no exception. The authors proposed several interesting lines of research. Firstly, they discussed the role of timing in emotion recognition. Much of the research conducted on this topic varies with the type of stimuli used, be it static images or dynamically moving videos. Both kinds of stimuli present unique advantages and disadvantages, so the subsequent conclusions must always be considered through a specific lens. As video data becomes more readily available and easier to manipulate or trim to elicit emotions, like specific facial expressions, it will be important that researchers begin to use dynamic, time constrained, spontaneous representations, and realistic emotions in their research.

Secondly, the authors offered another key area to focus on: differences in the recognition of different emotions. The authors of this meta-analysis presented tentative evidence to support the notion that individuals with ASD exhibit poorer recognition of negative emotions, like sadness, anger, or fear (Uljarevic & Hamilton, 2013). Authors of a subsequent meta-analysis published in 2014 suggested that individuals with ASD exhibited a strong and generalized deficit in facial expression recognition and that such a deficit increased in magnitude during development (Lozier et al., 2014). While this was not necessarily new information, the salient point was best represented through the results of another article. Lawrence and colleagues found that individuals with ASD classified as late- or post-puberty were better at recognizing anger and disgust than individuals with ASD classified at mid-puberty (2015). This further highlighted the importance of investigating the recognition capabilities of individuals with ASD using age as an independent variable.

Due to the relatively new updates to the DSM-5 regarding the severity of ASD as a determining qualifier when being diagnosed, research has been lagging behind regarding the differences in facial expression recognition deficits between ASD severity levels.

Summary

There is a lack of definitive research investigating the ability of those with ASD to process, interpret, and label facial expressions of emotions. Social communication deficits and weaknesses in correctly identifying facial expressions are predominant diagnostic criteria for individuals with ASD. Without the ability to correctly identify social cues like facial expressions, it becomes nearly impossible for individuals with ASD to achieve success in the social world. As such, in this study, I sought to measure children and adolescents' ability to label facial expression valence. By understanding their ability to label facial expressions, schools and school psychologists can better treat individuals with ASD.

Chapter III

Methodology

Introduction

The purpose of this study was to evaluate the ability of children with ASD to recognize and label nonverbal dynamically moving facial expression valence. In this chapter, I will outline the methodology, design, and research questions of this project. Additionally, I will provide details on the specific independent and dependent variables, sample, and statistical analyses that were conducted following the data collection.

Statement of the Problem

To date, there has been very little quantitative research investigating the social communications deficits in individuals with ASD using dynamic videos. Most research conducted has used static images of intense facial expressions (Griffin et al., 2021; Uljarevic, 2013). Very rarely, in-real-life social displays of emotion are static and intense. When given an opportunity to see a dynamically moving, spontaneous, real-time display of emotion, can children and adolescents more accurately label facial expressions of emotion? Through this study, I sought to investigate this question further.

Research Question 1: Does ASD severity level and age predict accuracy of labeling facial expression valence?

> **Hypothesis 1:** It is expected that as ASD severity level and age are significant predictors of the accuracy of labeling facial expression valence.

Research Question 2: What facial expression valence is most often correctly labeled by children with ASD?

Research Question 3: What facial expression valence is most often incorrectly labeled by children with ASD?

Methodology

To investigate the proposed research questions, a quantitative methodology was selected to provide measurement of a cognitive process: emotion processing. Emotion processing, like any other cognitive process (e.g., attention, executive functioning), can be measured using many combinations of research methodologies and assessment tools. In this study, the design was a non-experimental correlational predictive study wherein variables (age, ASD severity level) were being used to predict accuracy of labeling facial expressions.

Research Design

The design of this study was a cross-sectional non-experimental correlational predictive research design, which involved comparing two or more groups of people while not manipulating independent variables. Additionally, random assignment to conditions was not possible. A cross-sectional non-experimental design was the most appropriate design for the research questions and could account for the limitations posed by the COVID-19 global pandemic. A control group was not included as a part of this research. During the planning stages of this research project, due to limited access to in-person research due to IRB COVID-19 restrictions, the recruitment of a control group was not believed to be feasible. Participants were assigned to groups based upon researcher discretion. Age and ASD severity served as the independent variables. The participants' accuracy of labeling facial expression valence was the dependent variable for this research study.

Independent Variables

Age. Age was measured as the participants' age on the day the survey was completed. Age was measured as a continuous variable measured in whole years. Bowen and Atwood (2004) state that aging was the accumulation of changes in a human being over time. In the context of this study, age was measured by the age in years of the participant on the day of data collection.

ASD Severity Level. Autism spectrum disorder (ASD) severity level was defined according to the system employed in the DSM-5 but using only the social communication descriptors. ASD severity level was measured as a categorical variable. Each severity level was assigned a numerical value on three levels: Level 1=1, Level 2=2, and Level 3=3. Level 1 was defined as "without supports in place, deficits in social communication cause noticeable impairments" (APA, 2013, p. 52). Level 2 was defined as "marked deficits in verbal and nonverbal social communication skills; social impairments apparent even with supports in place" (APA, 2013, p. 52). Level 3 was defined as "severe deficits in verbal and nonverbal social communication skills cause severe impairments in functioning, very limited initiation of social interactions, and minimal response to social overtures from others" (APA, 2013, p. 52). Participant ASD severity level was collected with a question completed by their parent or guardian. Parents/guardians selected if their child "required support" (Level 1 defined above), "required substantial support" (Level 2 defined above), or "required very substantial support," which equated to Level 3 which is defined above. Total score for ASD severity level was calculated with possible scores ranging from 1-3.

Dependent Variable

The dependent variable of this study was the participants' ability to correctly label facial expression valence of happy, neutral/no expression, or sad measured as a ratio of total correct.

Accuracy was defined in this study as the ability to correctly label facial expressions (correct or incorrect). It was measured as a ratio of total correct (total correctly identified/total videos). Next, accuracy was quantified for each of the three expressions (happy, sad, neutral; total expression specific correctly identified/total number of expression specific videos). In total, there was 26 videos with 10 “happy” videos, 8 “sad” videos, and 8 “neutral/no expression” videos. Finally, accuracy was quantified on an item-specific level wherein it is considered a dichotomous, categorical variable quantified as correct or incorrect.

Pantic (2008) defines facial expression recognition in three steps:

1. Locating faces in the scene (e.g., in an image; this step is also referred to as face detection)
2. Extracting facial features from the detected face region (e.g., detecting the shape of facial components or describing the texture of the skin in a facial area; this step is referred to as facial feature extraction)
3. Analyzing the motion of facial features and/or the changes in the appearance of facial features and classifying this information into some facial expression-interpretative categories such as facial muscle activations like smile or frown, emotion (affect) categories like happiness or anger, attitude categories like (dis)liking or ambivalence, etc. (this step is also referred to as facial expression interpretation).

For this study, the videos were presented in real-time motion. The participant could watch the video as many times as was necessary. Additionally, they could pause the video at any moment. The process of the video selection, including expressions and target frames for scoring will be explored in greater detail in subsequent sections of this chapter.

Population and Sample Selection

Participants included youth between the ages of 4 and 21 years 11 months old that are or have been previously diagnosed with ASD. The population available for this study was any person diagnosed with ASD under the age of 21 years and 11 months. This age included all school-eligible individuals in the United States, and therefore, was chosen as the ceiling age cutoff.

After receiving Institutional Review Board approval, various local, state, and national organizations and clinical and school-based professionals were contacted via e-mail by the researcher. Additionally, assistance was sought from current and former colleagues and supervisors of the researcher. A total of 10 organizations and professionals agreed to distribute the link to an unknown number of individuals within their own organizations, schools, and offices. Ninety-two individuals opened the program with n=31 of them completing the entirety of the task. The final sample size of the study was n=31. Due to the widespread nature with which the study link was distributed, it is impossible to say with certainty how many people were exposed to it.

To determine the sample size, a G*power analysis was conducted (Faul et al., 2009). Effect size (*F*) in a recent meta-analysis published on the last 40 years of research on face recognition deficits of ASD calculated effect sizes for the age variable (Griffin et al., 2020). The published effect size was .20. It was expected that as age increased, so would the accuracy. G*Power analysis revealed a critical *F* value = 3.19 and a sample size of n = 52 with actual power = 0.81. For the purposes of this study, a sample of n = 52 would have been needed to achieve a power of .80. Post-hoc G*power analysis revealed an achieved power of 0.36 given the achieved sample size of n = 31 and $F(2,28) = 0.121$.

Participants' age was limited to > 4 years in order to have the necessary physical and cognitive abilities to properly operate a computer, and < 21 years, 11 months, as most of the literature has focused on children between birth and 21 years. Additionally, individuals older than 21 years, 11-months exceed the oldest age to be eligible to attend school in the United States. In total, 31 parents and/or guardians gave consent for their child's participation. The participants consisted of 14 male participants, 14 female participants, 1 transgender participants, and 2 participants did not report a gender. Age of the participants ranged from 4 years old to 21 years old. Following the end of the data collection phase, 0 participants dropped out, 0 expressed a lack of interest or motivation, and 0 not expressing any reason.

Research Instruments

Binghamton-Pittsburgh 3D Dynamic Spontaneous Facial Expression Database

Facial expression videos were generated using the Binghamton-Pittsburgh 3D Dynamic Spontaneous Facial Expression Database (BP4D+; Zhang et al., 2016). This database offered high definition spontaneous facial expressions from a diverse group of young adults. Emotions were elicited using well-validated approaches. The process to elicit specific emotions were designed and implemented using previously researched and validated methods. The database included forty-one subject faces (23 women, 18 men). The subject faces ranged from ages 18-29. Eleven were Asian, 6 were African American, 4 were Hispanic, and 20 were Euro-American. Following each emotion elicitation task, each participant was asked what emotion they experienced, allowing for self-report emotion labels for each video (Zhang et al., 2016).

Reliability of the BP4D+ Database

Methods used to elicit target emotional expressions were first pilot tested and then utilized in the laboratory environment. The methods used evoked a range of authentic and spontaneous facial expression of emotions (Cowie & Cornelius, 2003). As such, the video data used in this study was considered valid and generalizable across settings and subjects. Additional reliability of the instrument was reported using the kappa reliability coefficient. Interrater reliability was an average calculated from 27 manually coded action units with an overall reported kappa of .931 (Ekman & Friesen, 1971; Zhang et al., 2016).

Reliability of the video data was measured as a kappa coefficient from multiple raters for expression categories. The overall kappa value for the emotion labels is 0.5535 (Zhang et al., 2016). Of the 2 basic emotion labels that were used as a part of this study, the highest measured kappa value was happy (kappa = 0.6335), while the lowest was sad (kappa = 0.4325).

Validity of the BP4D+ Database

The reason this database was chosen was its attempt at recording genuine and spontaneous displays of emotions. Un-posed or spontaneous facial expressions differ along several dimensions, including complexity and timing (Zeng et al., 2007). Deliberately posed expressions of emotions are slight but noticeably different from their spontaneous counterparts. Regarding validity of the instrument, this allowed for greater generalizability of results. Additional measures were undertaken by the creators of the instrument to further ensure its reliability and validity. Namely, the quality and usefulness of the instrument was evaluated through a series of software applications in spontaneous facial expression recognition (Zhang, et al., 2016).

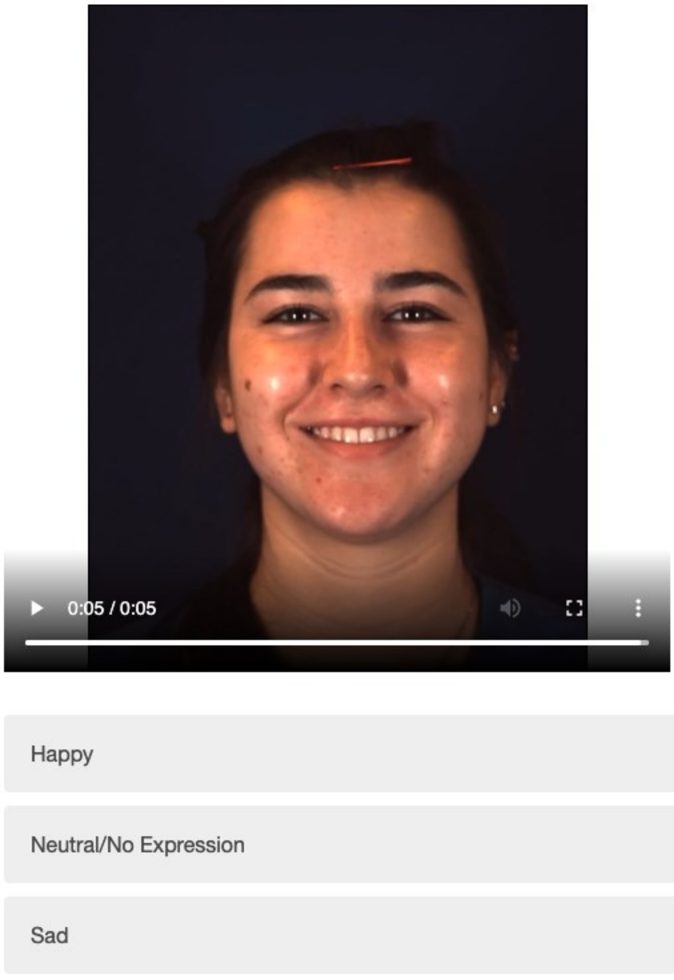
Since 2016 when BP4D+ was first published, 31 research articles and conference presentations have been authored that utilized the database in some capacity. While many of the articles have focused on furthering the literature base on the understanding of facial expressions, computer scientists, biologists, and medical doctors among many other professionals have utilized it in the approach towards new research questions (Chu, 2017; Ernst et al., 2020, 2021; Ertugrul et al., 2019, 2020; Fabiano, 2019; Fabiano & Canavan, 2019a, 2019b; Girard et al., 2019; Hinduja & Canavan, 2020; Hinduja et al., 2020a, 2020b; Jannat et al., 2018, 2020; Li et al., 2021; Lin et al., 2019; Liu et al., 2020; Liu & Yin, 2017; O'Sullivan, 2019; Reale et al., 2019; Shao et al., 2021; Sharma, 2018; Sharma & Canavan, 2021; Wang et al., n.d.; Yang et al., 2018, 2019; Zhang & Yin, 2021). The BP4D+ database has been validated as a quality tool useful for many different types of professionals, research questions, and research designs.

Procedures

Following the consent agreement, parents or guardians were asked a series of questions about their child. Following completion of the parent/guardian questions, but before the child began their section, the parent/guardian was asked to agree to not help their child with the activity once it began. If they agreed, the screen prompted them to bring in their child. Assent was collected from the child before participation. The parent was instructed to only offer moral support whenever needed. They were also asked to refrain from offering answers to their child. Following assent, the participant proceeded to label facial expressions. They spent approximately 10 minutes identifying 26 faces, but the task was completed in as little as 5 minutes. An example of the interface is included below (Image 1).

Image 1

Example of the User Interface



The interface played 4-7 second videos of faces pre-selected from the BP4D+ database (Zhang et al., 2016). Each video was selected based upon the participant in the video's self-report of their expression, which was collected after each task during data collection in BP4D+. Once videos were selected based on this criterion, approximately 4 to 9 second clips were edited. The segments were selected with three criteria in mind: 1) a visible onset of the target expression, 2) the intensity of target expression, and 3) the lack of additional facial expressions. Clips were narrowed down to the final 26 videos, which had achieved all three of the inclusion criteria. The video repeated as long as the participant did not select their desired expression label. Once selection of the label occurred, the participant had to select the arrow to move to the next video. The participant was unaware of how many total videos were labeled. After completion, the screen provided a message of gratitude and asked them to close the browser window.

Data Analysis

Research Question 1: Does ASD severity level and age predict the accuracy of labeling facial expression valence?

Hypothesis 1: It is expected that as ASD severity level and age are significant predictors of the accuracy of labeling facial expression valence.

Statistical Analyses: A multiple regression is appropriate for this research question because the dependent variable (DV; Ratio of accurately labeled facial expressions valence) is continuous in nature.

Statistical Assumptions: Multiple regression adheres to two sets of assumptions. The first regards the raw scale variables, while the second tackles the residuals. (Tabachnick & Fidell, 2007). The independent variables are fixed and measured without error. The relationship between the independent variables and dependent variable is linear (i.e., the assumption of linearity). Regarding the residuals, the mean of the residuals for each observation on the dependent variable over many replications is zero. The errors are normally distributed, not correlated, and independent. Finally, the variance of the residuals across all values of the independent variable is constant. This final assumption is also known as homoscedasticity.

The first assumption – the assumption of independence – is related most to the design of the study. While the sample was randomly selected, it was impossible to randomly assign participants to treatments. To prevent violation of this assumption, participants and their parent or guardian were required to complete consents and assents confirming that they will only participate once in this study. Regarding the second assumption – the assumption of normality – a violation is difficult when sample sizes are relatively large. There are a few ways to test for a violation of normality.

First, a visual analysis of the distributions occurred. I generated histograms independent variable and searched for any marked departures (extreme values) from normality. It appeared one such value was present but otherwise it was safe to assume the assumption of normality had not been violated. After the visual analysis of the histogram, a similar process was undertaken regarding the residuals plot. I next tested for significance of skewness and kurtosis. Finally, I utilized a Levene's Test for the goodness-of-fit for the ASD severity independent variable. This was conducted because this variable is a categorical variable. The problem that I encountered when conducting these tests was that my data did not involve groups with equal sample sizes. For a variety of reasons, more severe children with regards to ASD severity level not well represented in my sample.

Research Question 2: What facial expression valence (happy, sad, neutral/no expression) is most often correctly labeled by children with ASD?

Research Question 3: What facial expression valence (happy, sad, neutral/no expression) is most often incorrectly labeled by children with ASD?

For Research Questions 2 and 3, descriptive statistics including minimum and maximum, mean, standard deviation, and frequencies of ratio of correctly identified were calculated.

Ethical Considerations

From an ethical perspective, adjustments were made to conform to current IRB COVID-19 guidelines. As such, remote data collection methods were developed. The literature base prior to this has largely reflected the use of in-person methodologies. As such, data was collected from a protected population according to Duquesne University's IRB guidelines for human research. Participation in this research posed no threats to their health or safety. Additionally, they were given the opportunity to discontinue their participation at any point during data collection. Their participation helped contribute to the expanding research base on this topic and expanded the knowledge in this area with this population.

Summary

The purpose of this study was to evaluate children with ASD's ability to recognize and label non-verbal dynamically moving facial expression valence. Participants were from 10 local, state, and national organizations, school, and clinical professionals, and other mental health professionals. Participants were recruited using a sample of individuals currently diagnosed with an autism spectrum disorder. Descriptive statistics and a multiple linear regression were the main statistical analyses used to determine children with ASD's accuracy of labeling facial expression valence. In the next chapter, I will describe the results obtained from the analyses completed in response to the research questions posed.

Chapter IV

Results

In this chapter, I present the descriptive statistics for the demographic characteristics of the sample population. I also conducted analyses to test the hypotheses and analyze the potential differences between the sampled population.

Descriptive Analyses

The descriptive analyses in Table 1 showed that there were an equal number of males (n=14) and females (n=14) in the sample. One participant indicated they identified as non-binary/transgender, and 2 participants did not report their gender, which equated a total sample of n = 31. The age of the participants ranged from 4 years old to 21 years old (Table 2). The average age of the participants was 12.90 years old (Table 4). For 24 participants, their autism traits were noted to impact them at level 1 "requiring support", 2 participants were described as an individual in the level 2 "requiring substantial support" severity level, 1 participant fell in the level 3 "requiring very substantial support" ASD severity level, and 3 participants omitted this information when completing the study (Table 3).

Table 1

Gender Statistics

	N	%
Male	14	45.2
Female	14	45.2
Non-binary/Transgender	1	3.2
Missing System	2	6.5
Total	31	100%

Table 2

Age Statistics

Year	N	%
4	1	3.2
5	3	9.7
6	1	3.2

7	2	6.5
8	1	3.2
9	2	6.5
10	2	6.5
11	1	3.2
14	3	9.7
16	3	9.7
17	1	3.2
18	4	12.9
19	2	6.5
20	2	6.5
21	1	3.2
Missing System	3	9.7

Table 3

ASD Severity Level Statistics

ASD Severity Level	N	%
1	24	77.4
2	3	9.7
3	1	3.2
Missing System	3	9.7

Table 4

Age Descriptive Statistics

						Skewness		Kurtosis	
	N	Minimum	Maximum	Mean	Std. Deviation	Statistic	Std. Error	Statistic	Std. Error
Age	29	4	21	12.90	5.518	-.185	.434	-1.477	.845

Research Question 1: Does ASD severity level and age predict the accuracy of labeling facial expression valence?

To ensure statistical assumptions were met for the multiple regression, the data were first screened. A visual analysis of the ASD severity level histograms suggested that the assumption of normality could have been violated. The Kolmogorov-Smirnov statistic for the age variable was not significant at a $p > .05$ level, which indicated that it was not normally distributed (p =

.052; Table 5). However, the statistic was only slightly beyond the threshold, which suggested that the violation of this assumption could be ignored.

Visual analysis of distributions of the two independent variables, age and ASD severity level, suggested that the assumption of normality had been violated (Figures 1 & 2). A statistical analysis of the two independent variables revealed a kurtosis value for the age variable beyond the acceptable limit of within -1.00 to 1.00 (Tabachnick & Fidell, 2007). Age kurtosis value was equal to -1.477 (Table 4). However, a visual analysis of the residuals plot revealed that linearity, normality, and homoscedasticity were tenable given the uniform distribution and relative grouping around a horizontal line (Figure 3; Tabachnick & Fidell, 2007).

Figure 1

Distribution of ASD Severity Level Variable

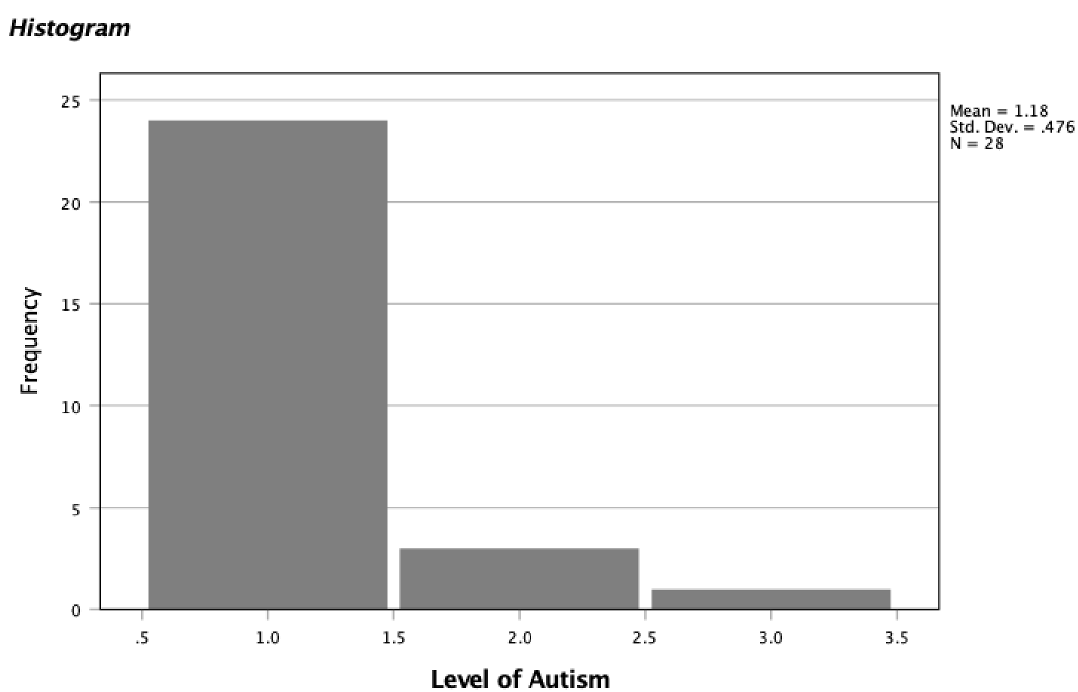


Figure 2

Distribution of Age Variable

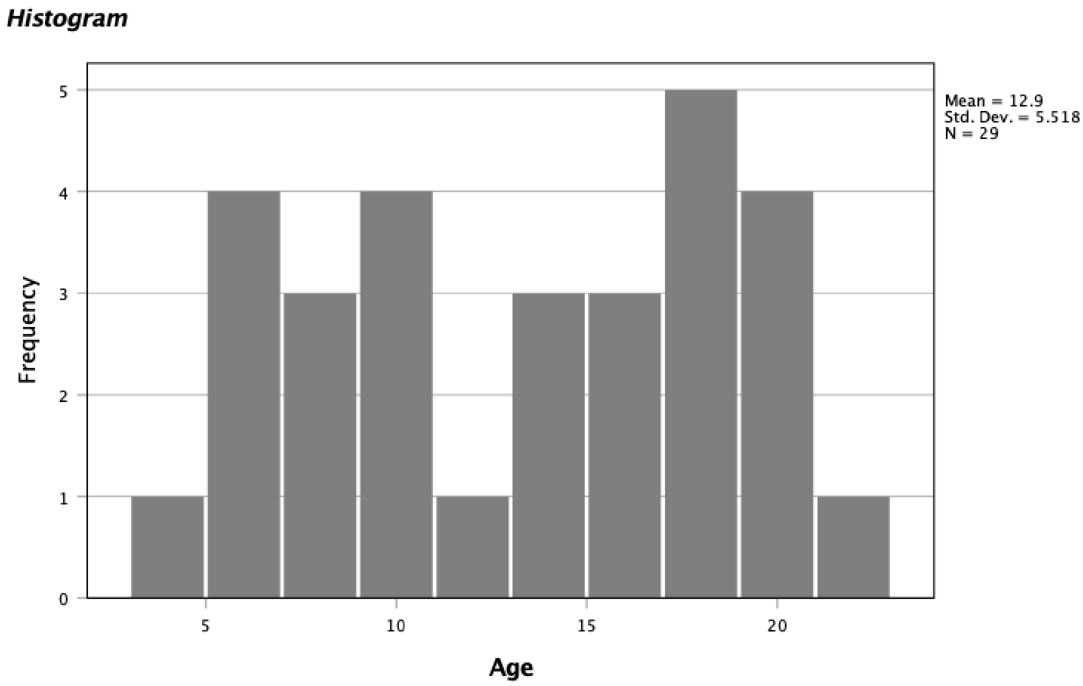


Figure 3

Residuals Plot for the Age Variable

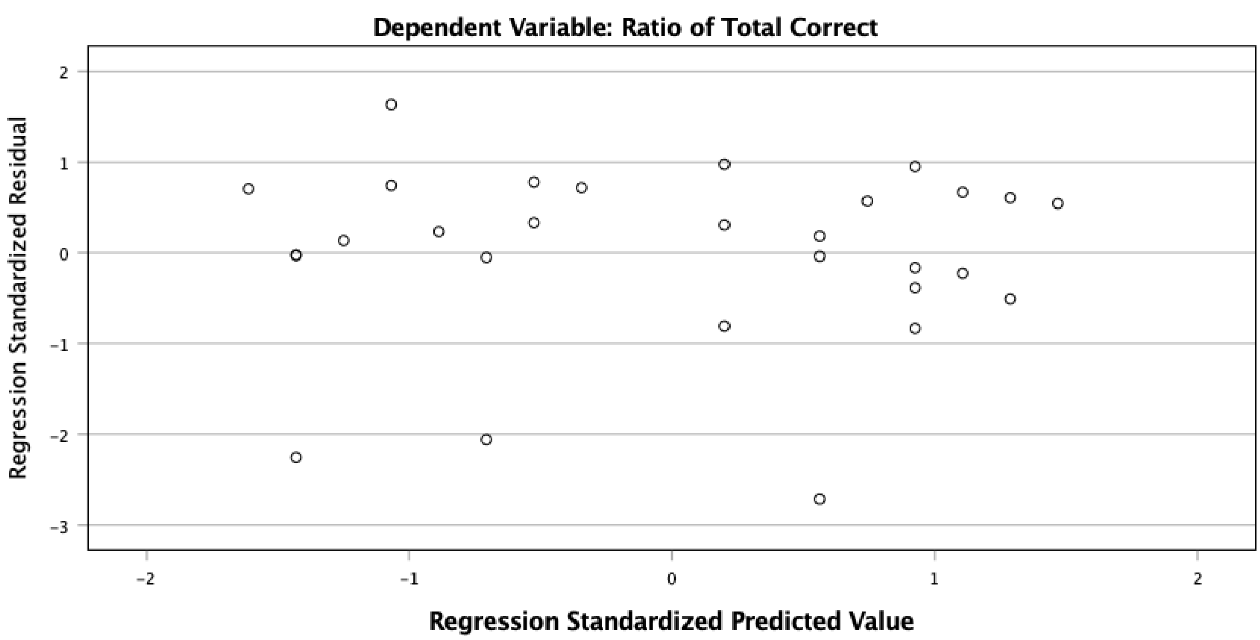


Table 5

Tests of Normality for the Age Variable

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Age	.161	29	.052	.913	29	.020

Next, a Levene's Test of Equality of Error Variance for the ASD severity level variable revealed a nonsignificant value, indicating there was not homogeneity of variance (p = .353; Table 6). The F Test of Heteroskedasticity revealed a nonsignificant p value, suggesting that the assumption of homoscedasticity was not violated for the age variable (p = 0.939; Table 7).

Table 6

Levene's Test of Equality of Error Variances for ASD Severity Level Variable

		Levene Statistic	**df1**	**df2**	**Sig.**
Ratio of Total Correct	Based on Mean	.895	1	25	.353
	Based on Median	.695	1	25	.412
	Based on Median with adjusted df	.695	1	23.485	.413
	Based on trimmed mean	.789	1	25	.383

Table 7

F Test for Heteroskedasticity

F	**df1**	**df2**	**Sig.**
.006	1	26	.939

A multiple linear regression was conducted to determine which independent variables (age; ASD severity level) were predictors of accuracy of labeling facial affect. Data screening did not eliminate any cases. Case 18 revealed an extreme Mahalanobis distance value of 14.69 that exceeded the critical $\chi 2$ value ($\chi 2$ critical = 13.816, p <.001) and an extreme Cook's distance value of 3.53 (Table 8). Exclusion of Case 18 did not impact the assumption of homogeneity. More importantly, Case 18 was the only participant in Level 3 of the level of autism variable, and as such, was critical to the analyses.

Table 8

Regression Outlier Statistics Extreme Values

			Case Number	Value
Mahalanobis Distance	Highest	1	18	14.69605
		2	5	4.58011
		3	1	3.63514
		4	16	2.99679
		5	3	2.23022
	Lowest	1	26	.14515
		2	22	.14515
		3	19	.14515
		4	13	.14515
		5	10	.14515
Cook's Distance	Highest	1	18	3.53333
		2	5	.45743
		3	30	.23496
		4	15	.09361
		5	1	.06160
	Lowest	1	26	.00004
		2	6	.00041
		3	23	.00052
		4	25	.00054
		5	14	.00054

A summary of the regression model is presented in table 9. Regression results indicated an overall model of two predictors that did not significantly predict accuracy in labeling facial affect [R^2 = .155, R^2_{adj} = .088, F(2, 25 = 2.297, p = .121] (Table 9). This model accounted for 15.5% of the variance in accuracy of labeling facial affect. The prediction equation is as follows: ratio of correct = .346*$X_{\text{ASD severity level}}$ + -.213*X_{Age} (Table 10).

Table 9

Model Summary

					Change Statistics					
Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	R^2 Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	.394	.155	.088	.17435	.155	2.297	2	25	.121	2.053

Table 10

Regression Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Tolerance	VIF
(Constant)	.691	.116		5.951	<.001		
ASD Severity Level	.011	.006	.346	1.876	.072	.996	1.004
Age	-.082	.071	-.213	-1.156	.258	.996	1.004

Table 11

ANOVA Summary Table

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	.140	2	.070	2.297	.121
	Residual	.760	25	.030		
	Total	.900	27			

Based on the ANOVA summary table results, accuracy of labeling facial expression affect was not significantly different based on the participants' age and ASD severity level, $F(2, 25) = 2.297$, $p = .121$ (Table 11).

Research Question 2: What facial expression valence (happy, sad, neutral) is most often correctly labeled by children with ASD?

Research Question 3: What facial expression valence (happy, sad, neutral) is most often incorrectly labeled by children with ASD?

For Research Question 2, participants were most accurate labeling facial expressions of happy, doing so 90.67% of the videos (Table 12). Results to answer Research Question 3 can be gleaned from table 12, which showed that the sad faces were, on average, the least correctly labeled facial expression at 47.92% accuracy.

Tables 13, 14, and 15 outline what participants were most likely to select as their answer for every individual video sorted by facial expression. Table 13 includes all 10 happy videos, table 14 includes the data for every neutral/no expression video, and table 15 includes the expression selected by participants for every sad video. Neutral/No Expression video 6 was the only neutral/no expression video that was below 80% correctly labeled. In sad videos 3, 6, and 7, more than 50% of the participants selected Neutral/No Expression and Happy combined.

Table 12

Average Total Performance of Ratio of Labeling Facial Affect

	N	Minimum	Maximum	Mean	Standard Deviation
Happy	30	.30	1.00	.9067	.17798
Sad	30	.00	1.00	.4792	.27284
Neutral/No Expression	30	.00	1.00	.8083	.22680

Table 13

Total Performance of Labeling
Dependent Variable: **Happy Videos**

Video Number	Expression Selected by Participant							
	Happy		Neutral/No Expression		Sad		Missing System	
	N	%	N	%	N	%	N	%
Happy Video 1	26	86.7	2	6.7	1	3.3	1	3.3
Happy Video 2	28	93.3	2	6.7	0	0.0	0	0.0
Happy Video 3	27	90.0	2	6.7	1	3.3	0	0.0
Happy Video 4	29	96.7	1	3.3	0	0.0	0	0.0
Happy Video 5	29	96.7	1	3.3	0	0.0	0	0.0
Happy Video 6	29	96.7	0	0.0	0	0.0	1	3.3
Happy Video 7	24	80.0	5	16.7	0	0.0	1	3.3
Happy Video 8	25	83.3	3	10.0	1	3.3	1	3.3
Happy Video 9	27	90.0	2	6.7	0	0.0	1	3.3
Happy Video 10	28	93.3	1	3.3	0	0.0	1	3.3

Table 14

Total Performance of Labeling
Dependent Variable: **Neutral/No Expression Videos**

Video Number	Expression Selected by Participant							
	Happy		Neutral/No Expression		Sad		Missing System	
	N	%	N	%	N	%	N	%

Neutral Video 1	0	0.0	25	83.3	5	16.7	0	0.0
Neutral Video 2	1	3.3	24	80.0	5	16.7	0	0.0
Neutral Video 3	4	13.3	24	80.0	2	6.7	0	0.0
Neutral Video 4	2	6.7	27	90.0	1	3.3	0	0.0
Neutral Video 5	4	13.3	24	80.0	2	6.7	0	0.0
Neutral Video 6	2	6.7	19	63.3	9	30.0	0	0.0
Neutral Video 7	1	3.3	26	86.7	2	6.7	1	3.3
Neutral Video 8	1	3.3	25	83.3	3	10.0	1	3.3

Table 15

Total Performance of Labeling
Dependent Variable: **Sad Videos**

	Expression Selected by Participant							
Video Number	**Happy**		**Neutral/No Expression**		**Sad**		**Missing System**	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Sad Video 1	1	3.3	12	40.0	17	56.7	0	0.0
Sad Video 2	1	3.3	13	43.3	16	53.3	0	0.0
Sad Video 3	2	6.7	17	56.7	11	36.7	0	0.0
Sad Video 4	3	10.0	15	50.0	12	40.0	0	0.0
Sad Video 5	1	3.3	11	36.7	18	60.0	0	0.0
Sad Video 6	2	6.7	16	53.3	12	40.0	0	0.0
Sad Video 7	0	0.0	18	60.0	12	40.0	0	0.0
Sad Video 8	1	3.3	11	36.7	17	56.7	1	3.3

Chapter V

Discussion

In this chapter, I will focus on interpreting the findings of the current study. The results will be interpreted how they are related to the research questions and hypotheses. Next, the potential study limitations will be discussed, and conclusions of the study including future directions for research and practice will be offered.

Summary of Findings

In this study, I measured individuals diagnosed with an ASD's ability to accurately label the valence of facial expressions. I examined the differences between the overall accuracy of labeling videos as age and ASD severity level changed, as few studies have utilized a novel approach to facial expression identification where both videos *and* videos of spontaneous expressions were utilized. The use of videos allowed the participant to watch the onset and intensification of an expression, as opposed to a still image where neither are accessible. Additionally, spontaneous expressions, as opposed to their non-spontaneous counterparts, represents the expressers actual, unmitigated emotional experience (Namba, Makihara, Kabir, & Miyatani, 2017). Through this study, I sought to add to the growing literature base of facial affect recognition by individuals with ASD. Contributing to this literature is important because autism is diagnosed on two primary areas of deficit: 1) difficulties with social communication and 2) restricted and repetitive interests or behaviors. Human social communication involves a variety of both verbal and nonverbal cues. While not a direct diagnostic criterion for ASD, deficits in the facial affect recognition have been shown over the past 40 years of research as a contributing factor to social communication difficulties (Griffin, Bauer, & Scherf, 2021).

One primary source of inspiration for the design of this study was the utilization of videos, as opposed to still images of facial expressions. This decision was based in a desire to further contribute to the literature base considering advancements in technological-based assessment methods. The use of iPads, for instance, has become a much more widely utilized tool by psychologists. iPad assessments and questionnaires allow practitioners to increase accessibility to tests, provide more comprehensive assessment batteries, and reduce the chance human error occurs during administration and scoring procedures (Jellin, 2015). There are many widely used neuropsychological tests of facial affect recognition, which include, but are not limited to, the Cambridge Face Memory Task (CFMT; Duchaine & Nakayama, 2006), the Wechsler Memory Scale (WMS; Wechsler, 1997), and the Developmental NEuroPSYcholgical Assessment (NEPSY; Korkman, Kirk, & Kemp, 2007), and the Benton Face Recognition Test (BRFT; Benton, Sivan, Hamsher, Varney, & Spreen, 1983). The BRFT is a recognition task, which differs from the other listed assessment measures. This task involves the individual identifying a picture based on a specified emotion.

Regardless of the type of facial affect stimuli, all of these tasks involve pictures of facial expressions. These representations of facial expressions are static, often posed (as opposed to spontaneous), intense, and free of blending of other facial expressions (e.g., happy mixed with surprise). There is a reason many of the tasks previously utilized in research were designed this way. Above all else, pictures provide a clear, well-defined portrayal of a facial expression. Researchers in a recent meta-analysis found after analyzing 112 articles utilizing many of the assessment measures listed above, that individuals with ASD were reliably 1 standard deviation below their typically developed peers on facial affect recognition (Griffin, Bauer, & Scherf, 2021). How the results of the current study differ from much of the previous results is likely accounted by the type of facial affect stimuli.

Q1: Does ASD severity level and age predict accuracy of labeling facial expression valence?

Based on the results discussed in the previous chapter, neither a participants' level of ASD severity or their age were significant predictors of facial expression valence labeling. Furthermore, neither independent variable, age or ASD severity level, had a significant impact on their overall accuracy of labeling facial expression valence.

One possible explanation for these findings can be gleaned from recent updates in the practice of diagnostics. In 2013, the American Psychiatric Association published the Diagnostic and Statistical Manual, Fifth Edition wherein the diagnostic criteria for Autism Spectrum Disorder and previously associated disorders were reorganized. As part of that editing process was the addition of the ASD severity level qualifier. Prior to the DSM-5, the diagnosis of ASD did not require the clinician to specify an ASD severity level or make comments regarding co-occurring intellectual or language impairments. Despite this, research on facial affect in ASD has most often been limited to the inclusion of individuals with "Asperger's Disorder" or "High-Functioning ASD." As such, there is limited research, particularly since the update of the DSM-5 in 2013, on how differing ASD severity levels might impact overall facial recognition and facial affect recognition (Eussen et al., 2015; Griffin et al., 2021; Lozier, 2014). This will be explored more in-depth later in this chapter.

Prior to the update of the DSM, researchers often utilized overall intellectual abilities to differentiate individuals within the ASD population. Research outcomes utilizing both age and intellectual abilities found that age accounts for varying degrees of deficit with facial affect recognition, but intellectual abilities do not. While not a direct comparable to ASD severity level, overall intellectual abilities have been found to be negatively correlated with ASD symptom severity (Hill et al., 2015). That is, as intellectual abilities increase, ASD symptom severity decreases.

In this study, neither age nor the interaction between age and ASD severity level could account for the variance in overall accuracy. Similarly, neither age nor ASD severity level could predict accuracy of labeling facial expressions. The bulk of the research published over the past 40 years has demonstrated consistent differences in facial affect recognition for variables like age, sex, and intelligence quotient (IQ; Griffin et al., 2021). In contrast to some of previous research detailed above and in previous chapters (Mancini et al., 2013), individuals with ASD in this study did not differ in their accuracy in labeling videos of facial expressions based on age. A video, as opposed to a picture, offers the participant the chance to observe the onset (or offset) and subsequent intensification of the facial expression. The participant had the opportunity to control the video, watching it multiple times, starting, and stopping it as they needed. The final frame of each video selected for this study was intended to be the most intense frame of expression specific to that video. Perhaps with the greater control and independence with how they observed expressions, participants were able to be more accurate when labeling facial affect, regardless of their age or ASD severity level.

Q2: What facial expression valence is most often correctly labeled by children with ASD?

Q3: What facial expression valence is most often incorrectly labeled by children with ASD?

Based on the results of this study, participants, regardless of age or ASD severity level labeled happy videos correctly around 91% (average ratio = .9067). The average accuracy of neutral faces was around 81% (average ratio = .8083), making sad faces the most incorrectly labeled video at around 48% correct (average ratio = .4792). Participants were, on average, more likely to label a sad video as either happy or neutral than they were to label it as sad. These results are inconsistent with previous research that indicated the largest age-related increases in accuracy of facial affect recognition occurred with both neutral and sad faces (Mancini et al., 2013). Furthermore, when participants were incorrect in their labeling, they overwhelmingly believed that a sad video was in fact a video of a neutral or no expression video. During real-world social contexts, this misinterpretation could have a multitude of negative outcomes. For example, this mistake could impact an individual with ASD's ability to match a specific social interaction with the social cue, in this case a facial expression.

Summary

Overall, neither age, ASD severity level, or the interaction could reliably predict overall accuracy in labeling facial expression valence. These results differ from the bulk of the previous research in that age did not account for differences in facial affect recognition in the current study. This could be due to the different delivery method of facial stimuli, namely videos in the current study as opposed to pictures over the past 40 years of research.

Potential Study Limitations

As with any research study, there are multiple limitations to consider. Firstly, the sample included in the analyses included only one participant who was diagnosed as an individual in the level 3 "requiring very substantial support" qualifier. Perhaps more salient is the impact on the expected versus achieved statistical power. A priori power analysis for the regression analyses revealed a sample size of n = 91 to achieve an actual power of 0.80. However, exhaustive distribution efforts only yielded a total sample size of n = 31. Post-hoc G*power analysis revealed an achieved power of 0.36 given the achieved sample size of n = 31 and $F(2,28) = 0.121$. With such a drastic decrease in the statistical power, the interpretability of the regression analyses were called into question. Despite continuing to conduct the regressions with the achieved sample size and subsequent a prior statistical power, there was even less confidence whether rejecting or not rejecting the null hypothesis based on the calculated statistical significance was correct. Due to the difficult nature of not only accessing individuals with ASD, but specifically individuals in the most severe level of ASD, the confidence to run the regression and know that the results were generalizable to the population was lower based on the actual statistical power.

Secondly, participants were provided the opportunity to watch the videos as they were labeling them as many times as they needed. One of the major benefits to utilizing videos as opposed to pictures was their inherent ecological validity. However, that factor was negatively impacted by allowing the participant to view the same expression more than once. Rarely, perhaps even impossibly, can the same exact expression be repeated in a real world scenario. One hypothesis posited by researchers investigating facial affect deficits in individuals in ASD is that perhaps nonverbal communications in real-world social situations (e.g., facial expressions, body language, etc.) are quick, fleeting, and low in intensity. This makes detection for individuals with ASD much more difficult when compared to their similar-aged neurotypical peer (Dapretto et al., 2006). By allowing the participants to view the videos as many times as they needed, the chance to miss a key component was lessened. Despite that, it meant that the generalizability was negatively impacted. As such, the ability for the participant in the present study to be able to watch and re-watch the video unlimited times was considered a potential limitation of the design.

Additionally, the response rate of participants is a potential limitation of this project. During multiple phases of distribution to more than 200 individuals, professionals, organizations, and associations, only ten representatives agreed to distribute the project to individuals they believed met the inclusion criteria. Based on Qualtrics statistics, the project was opened 92 times. This includes the n = 31 individuals who completed the project in its entirety. The sample size was small compared to the response rate, suggesting additional barriers or design limitations that prevented individuals from completing their full participation. This ratio of response rate to sample size contributed negatively towards the external validity. Based on the estimated nonresponse rate based on the 200 or more individuals the survey was shared with, it is fair to state that the sample does not represent that population. As such, it is difficult to generalize the results of the study to the population.

There is limited published research on the prevalence rate of each level of ASD severity. This could be due to several key factors. Firstly, the requirement of non-school psychologists to assign an ASD severity level was not required until the update of the DSM in 2013. Currently, diagnosing professionals in psychological settings outside of a traditional school diagnose ASD based on criteria from the DSM-5, which includes two primary diagnostic criteria, social communication deficits and restricted and/or repetitive behaviors (APA, 2013). Additionally, diagnosing clinicians currently are supposed to consider to what degree of support the individual requires, from the lowest level 1 (requiring support), level 2 (requiring substantial support), to the highest level 3 (requiring very substantial support). This current level of ASD severity qualifier first dates to the publishing of the DSM-5 in 2013. Previous versions of the DSM, namely the DSM-IV, did not require or include any language regarding the determination of a level of support required.

In addition to that, the most recent prevalence rates as reported by the CDC date back to 2014, just one year after the DSM-5 went into practice. Those prevalence rates were based on different settings and types of clinicians. Some of the data was based on school-based evaluations. Interestingly, school psychologists are responsible not for diagnosing, but for identifying students with a possible disability. The IDEA (2004) definition of the autism disability category reads as follows:

> "(i) Autism means a developmental disability significantly affecting verbal and nonverbal communication and social interaction, generally evident before age three, that adversely affects a child's educational performance. Other characteristics often associated with autism are engagement in repetitive activities and stereotyped movements, resistance to environmental change or change in daily routines, and unusual responses to sensory experiences. (ii) Autism does not apply if a child's educational performance is adversely affected primarily because the child has an emotional disturbance, as defined in paragraph (c)(4) of this section. (iii) A child who manifests the characteristics of autism after age three could be identified as having autism if the criteria in paragraph (c)(1)(i) of this section are satisfied (IDEA, 2004)."

There is no requirement on school psychologists when identifying a student with a disability of autism (IDEA, 2004) to indicate what level of support they require from a DSM-5 perspective. While it is obvious from a statistical perspective that the uneven distribution between conditions of the severity levels of ASD independent variable represented a potential limitation to the study, it remained unclear whether the breakdown of each level of ASD was representative of the population.

The most salient reason why it is so important to consider assigning a severity level when diagnosing ASD is the impact on interventions. Specifically in Pennsylvania, individuals diagnosed with "an intellectual disability or autism spectrum disorder" can at the age of 21, gain access to certain social services, therapies, and interventions. The most important consideration comes when the individual applies for funding. Individuals with a more severe level of ASD (e.g., Level 3) typically receive more in funding than do individuals with a less severe level of ASD (Level 1; Office of Developmental Programs Bulletin, 2019). While the intention of this project was to investigate the differences in facial affect recognition between ASD severity levels, the findings and potential limitations should drive future research and diagnostic procedures of individuals with ASD. An important factor impacting these processes is further highlighted in Table 16.

Table 16

Profession of Diagnosing Clinician Frequencies

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Pediatrician	2	6.3	6.7	6.7
	School Psychologist	8	25.0	26.7	33.3
	Clinical Psychologist	16	50.0	53.3	86.7
	Other	4	12.5	13.3	100.0
	Total	30	93.8	100.0	
Missing	System	2	6.3		
Total		32	100.0		

Table 16 represents the array of professionals who were responsible for diagnosing or identifying participants from this current project. Participant’s parents or guardian selected the type of health professional that first indicated that their child was on the autism spectrum. Based on the results, at least 8 participants (school psychologists n = 8) were never presumably told directly what level of ASD their child met the criteria for. This likely represents the challenges with collecting prevalence rates for each level of ASD on a national or international scale. As such, there has been scarce, and more importantly, generalizable research published that includes level of ASD in the analyses.

Through an attempt to provide quantitative data of facial affect recognition of videos of expressions, therein lies an additional limitation of the study. Specifically, while utilizing video stimuli allows the observer to see the onset of the expression, there remains drawbacks of using videos of expressions as opposed to still images. Still images, as previously utilized in the bulk of the research spanning the previous 40 years, provide researchers total control over most aspects of the images. Researchers previously could manipulate images to make them appear more or less intense, select images that only included the intended facial expression, and control the lighting, angle, and direction of the person's face. In videos of spontaneous facial expressions, many of the same characteristics are not controllable, but rather natural to the participant.

Additionally, this current study emphasized the usage of spontaneous expressions rather than posed expressions. While there are morphological differences between facial expressions, researchers typically agree that posed expressions convey an emotion the person wants to convey, versus a spontaneous expression which represents the expressers actual, unmitigated emotional experience (Namba, Makihara, Kabir, & Miyatani, 2017). For example, observers typically rate spontaneous expressions of happy more positively than posed faces (Johnston, Miles, & Macrae, 2010). Additionally, spontaneous expressions are inherently rooted in both the expressors own emotional experience, but also intended to convey certain social cues (Hess & Kleck, 1997; Kunzmann, Kupperbusch, & Levenson, 2005). Despite the positives to utilizing spontaneous expressions, the potential for additional blending of other aspects of expressions makes drawing statistical inferences more challenging. There was a greater risk that the participant could have been distracted by, or influenced by, additional, unintended aspects of other facial expressions (e.g., aspects of a fear response in a predominantly sad video), gender differences, or different races or ethnicities of the individuals in the videos.

Finally, an important aspect of the BP4D+ database was a contributing factor towards a potential limitation of this project. The videos included in this study were generated from the BP4D+ video database (Zhang et al., 2014). Specifically, the happy videos were generated from "Task 1" from the database, neutral videos were generated from any "Task", and sad videos were generated from "Task 2". Following the completion of each task, the participant in the BP4D+ data collection was asked to report what was the primary emotion they experienced (Figure 3), and then rate how intensely they felt that emotion (Figure 4). Specifically, during Task 2 where the participant watched a clip from a documentary that was intended to elicit sadness, a majority of the participants did, as intended, self-report sadness as their primary emotional state. Despite that, the self-report statistics (Figure 3) indicated that this was the second lowest target-to-actual percentage of a primary emotion among the eight tasks. Only task 7 resulted in a lower total percentage of the primary targeted emotional state. In other words, the task designed to elicit sadness was the second lowest accurate task at elicited the intended emotion.

Figure 4 (from Zhang et al., 2014)

Primary Emotion Participants from BP4D+ Self-Reported They Experienced During Each Task

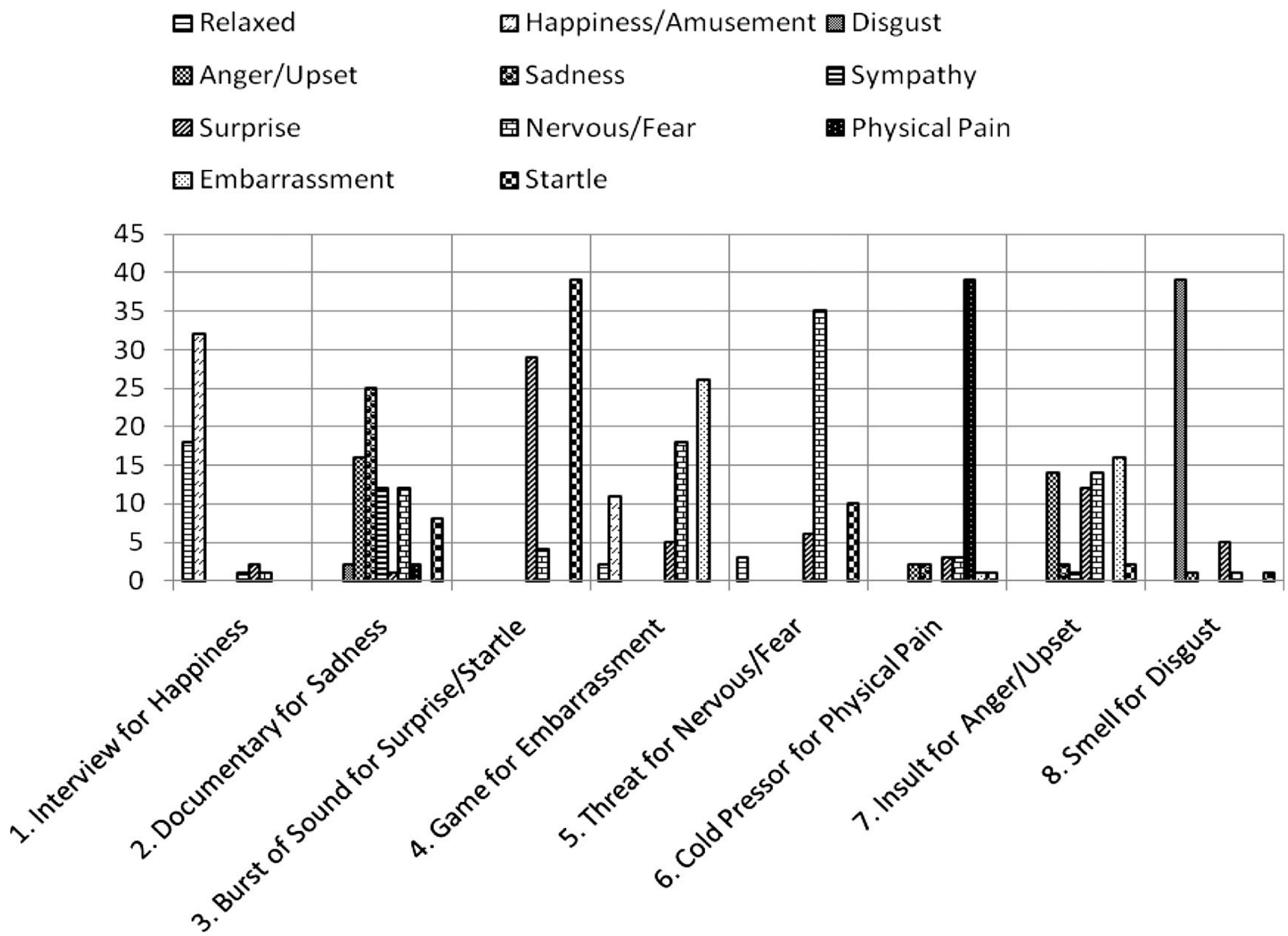
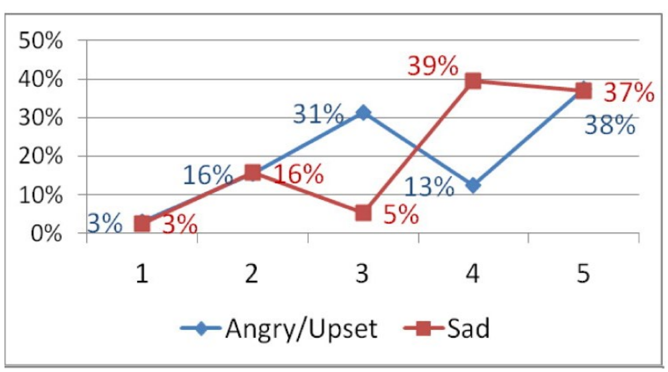


Figure 5 (adapted from Zhang et al., 2014)

Self-reported emotion distribution across 5 scales (very slightly, a little, moderately, quite a bit, extremely)



Furthermore, participants self-rated how intensely they experienced their primary emotion based on a 6-point Likert scale. Based on the results of the line graph in Figure 4, participants that experienced primarily anger were more likely at four of the five levels of intensity to express feeling equally or more intensely than participants who primarily experienced sadness. In other words, Task 2, which was designed to target sadness as a primary emotion was successful at doing just that (Figure 3). But in doing so, also frequently elicited feelings of anger, which was on average more intensely experienced than sadness (Figure 4). This is all to make the following point. The selection of happy and neutral videos for inclusion into this present study were shown to be easier to identify, more pronounced and intense, and often appeared without additional aspects of other facial expressions (Zhang et al., 2014). The fact that happy and neutral were far more accurately recognized than sad faces could reflect this shortcoming of the BP4D+ database.

Future Research Implications

In the future, researchers and test developers alike should continue to focus on measuring facial affect recognition deficits in individuals with ASD. However, they may want to design and incorporate more video-based research designs and assessment measures. As major test developers begin to offer many neuropsychological tests through iPads and other technologies, this creates new opportunities to reconsider how assessment materials can be altered to reflect real-world environments and daily functioning. This same line of methodology can be applied to intervention techniques, helping individuals, particularly children with ASD, learn how to better identify different aspects of the social world allowing them to experience more successful social functioning.

It will be important for future research to consider comparing affect recognition for individuals with ASD to their neurotypical peers utilizing video data. Along the same lines, researchers may consider measuring affect recognition for video data compared to still-images. As previously discussed, video data of spontaneous facial expressions likely represents more real-world situations that the individual could experience. At the same time, video stimuli could also be more difficult to recognize than a picture of the same facial expression due to the blending of other facial expressions, lower overall intensity, and/or shorter durations of facial expressions.

This current study focused on two primary universal facial expressions, happy and sad. An immediate consideration for future research is the addition of more, or all six of the universal facial expressions, to determine if, and by extension, specifically where, recognition of videos of facial expressions improves or declines. Additionally, the present study strived to only include very intense representations of facial expressions. Future research could look to determine at what point in the onset of a facial expression could an individual with ASD reliably recognize a specific facial expression. Finally, gender differences exist between biological males and biological females in ASD. It will be important for future researchers to consider how each gender interprets and processes facial expressions of emotion. Additionally, are there differences in the way biological males and females with ASD process female faces as opposed to male faces? This information could be particularly impactful regarding the interpretation of certain gender-specific questions posed on questionnaires utilized during psychological and neuropsychological evaluations.

Conclusions

Autism Spectrum Disorder is a neurodevelopmental disorder characterized by deficits with social communication and the presence of restricted and repetitive behaviors and interests. While not a criterion of ASD, facial affect recognition and discrimination deficits have been demonstrated to be a reliable deficit for individuals with ASD. The bulk of the research published over the past 40 years has demonstrated consistent differences in facial affect recognition for variables like age, sex, race, symptom severity, and intelligence quotient when observers are rating images of facial expressions. This study sought to measure how accurate individuals on varying levels of ASD severity and differing ages were at labeling videos of facial expressions of happy, neutral, and sad. Based on the results, neither age nor the level of ASD was a reliable predictor of facial expression valence recognition. There is a scarcity of research utilizing video stimuli as well as investigating how varying degrees of ASD severity impact facial affect recognition. As more psychological and neuropsychological assessments and interventions are designed to be delivered via video technology, clinicians and test developers alike could work towards re-developing how facial affect assessment measures and social skills interventions are delivered. By doing so, materials can more closely resemble everyday development and social functioning. Ultimately, the scientific understanding of facial affect recognition abilities in ASD can lead to more reliable tools for diagnosis and more targeted, efficacious, individualized interventions for a population that is becoming more prevalent year after year.

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