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Navigating the Sensory and Social World: An Exploration of Temperament and Autistic Traits

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Navigating the Sensory and Social World: An Exploration of Temperament and Autistic Traits

A Dissertation submitted in partial satisfaction of the
requirements for the degree
Doctor of Philosophy

in

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by

Hannah M. Van Etten

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The Dissertation of Hannah M. Van Etten is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

Chair

University of California, San Diego

2017

DEDICATION

To Gail Stellar, one of the smartest and strongest women I have ever known, who instilled in me a thirst for knowledge.

To Slackface, and all those associated.

EPIGRAPH

The unexamined life

is not worth living.

—Socrates

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ABSTRACT OF THE DISSERTATION

Navigating the Sensory and Social World: An Exploration of Temperament and Autistic Traits

by

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Doctor of Philosophy in Psychology

University of California, San Diego, 2017

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Children are exposed to a multitude of sensations on a daily basis. These sensation can be in the form of sensory input — such as visual, auditory, or tactile sensations — or in the form of social input — such as facial expressions, eye gaze, or body language. However, variation within children can influence the proficiency with which they recognize and interpret these sensory and social cues, as well as their ability to use social cues in the completion of social behaviors. While children can differ on a variety of dimensions, this dissertation examined two common sources of variation: characteristics of Autism Spectrum Disorder (ASD) and differences in

temperament. Utilizing a questionnaire designed to assess sensory difficulties, in Chapter One I demonstrate that risk for, and diagnosis of, ASD influence children's reactions to low level sensory stimuli, such that they engage in an increased prevalence of atypical sensory behaviors in comparison to children without risk for, or diagnosis of, ASD. In Chapter Two, I demonstrate that toddlers' social behaviors (i.e., smiling, vocalizations, eye gaze) during an imitation paradigm differ in response to positive and neutral displays of facial and vocal affect from a partner, but that variation in temperament does not have an influence on these social behaviors. Chapter Three provides evidence that variation in social communication ability (as measured by the presence of autistic traits) in typically developing children negatively impacts their ability to engage in prosocial behaviors according to parent-report, regardless of their ability to attend to social cues in their environment during an in-lab prosocial paradigm. Taken together, these three chapters demonstrate that characteristics of ASD impact children's response to their sensory environment and completion of social behaviors, but does not provide evidence for a strong role of temperamental variation.

Introduction

From the moment a child enters this world, they are thrust into a confusing and complex environment. After being in the womb with minimal external input, at birth they are suddenly overwhelmed by new sensations (e.g., auditory, visual, tactile), people, and experiences. They are forced to contend with sensory stimuli inundating them from all directions, and enter into complex interactions with social beings. As they develop, children are able to not only make sense of these sensory and social stimuli but also respond to, interpret, and use these cues to navigate the world effectively. However, not all children respond to cues in the same manner. The environmental cues to which children attend, and the interpretation of and subsequent behavioral reactions to these cues are influenced substantially by differences in norms for communication across societies (i.e., culture), differences across clinical populations (i.e., individuals exhibiting characteristics of, and risk for, Autism Spectrum Disorder (ASD)), and differences across individuals (i.e., temperament).

Sensory Cues

A first step to functioning optimally in a given environment involves the input and processing of low-level stimuli, such as auditory, tactile, vestibular, oral, and visual sensations. These sensory cues are constantly at play, making it important to identify which of these sensations needs attending to (such as the feeling of pain when touching something hot) and which can be ignored (such as the feeling of a tag on a shirt touching skin). If an individual is unable to ignore low-level sensory stimuli that are unimportant, or fail to attend to those stimuli that are important, this may cause difficulty in attending to higher-level stimuli later on. Children who displayed elevated signs of sensory hyper-responsivity also displayed increased internalizing, externalizing, and dysregulation problems and decreased adaptive social behaviors (Ben-Sasson, Carter, & Briggs-Gowan, 2009). Difficulties in processing and responding to sensory cues have also been shown to negatively impact social participation (Stagnitti, Raison, & Ryan, 1999) and have been associated with social-emotional problems (Kinnealey & Fuiek, 1999).

This variation in how individuals respond to sensory cues can manifest itself in the intensity in which sensory experiences are felt and the behavioral response to these experiences. While there is strong individual variation in response to sensory cues, some clinical populations display an increased prevalence of atypical responses to sensory cues. In particular, children at risk for developing ASD, and those who have a diagnosis of ASD, display difficulty in processing sensory cues and responding in the appropriate manner (e.g., Ben-Sasson et al. 2009; Germani et al., 2014; Mulligan & White, 2012). They frequently display unusual sensory behaviors, at times being hyper-responsive to sensory cues, and other times being hypo-responsive. Given that little research has been performed examining responses to sensory cues in children at a high risk for developing ASD, and that these behaviors vary with development and diagnostic clarity, Chapter One sought to examine how these groups differentially interpret and respond to low level sensory cues in their environment.

Social Cues

Once children are able to effectively respond to low-level sensory cues, they are then able to attend to the rest of their environment. Constantly, children assess the situation they are in and respond accordingly based on a variety of social cues in their environment. During typical development, children become increasingly more aware of these subtle cues and more adept at using them to inform their behavior. By 12 months, children use facial cues to guide their behavior (e.g., social referencing, Feinman, 1982; Moore & Corkum, 1994; Walden & Ogan, 1988) and direct their attention (e.g., joint attention, Carpenter, Nagell, Tomasello, Butterworth, & Moore, 1998) and by 18 months, are influenced by adults' facial expressions when making choices (Repacholi & Gopnik, 1997). However, responses such as these are not necessarily universal.

Various cultures place distinct emphasis on how social cues are used and interpreted during communication. In many Western, educated, industrialized, rich, and democratic (WEIRD; Henrich, Heine, & Norenzayan, 2010) cultures, such as the United States, a strong emphasis is placed on mutual eye contact when interacting with others. Early in infancy, eye gaze directed at a caregiver is the primary means of communication (Carpenter et al., 1998; Moore, 2008) and is frequently used throughout the life span when engaging in social interactions. This emphasis on eye contact is not universal, as other cultures dissuade the use of eye contact (e.g., the Yucatec Mayan, Gaskins, 2000; the Nso of Cameroon, Kärtner, Keller, & Yovsi, 2010; and the Gusii of Kenya, Richman, Miller, & LeVine, 1992). Differences between cultures can also be seen in the use of outward displays of emotion (e.g., Matsumoto, 1990; Wörmann, Holodynski, Kärtner, & Keller, 2012). For example, the onset of smiling differs based on the amount of face-to-face interaction infants have with caregivers

(Wörmann et al., 2012). While the research discussed in this dissertation focus on data gathered in a western culture, it is vital to remember and take into consideration that the reliance on, use, and interpretation of, social cues vary greatly from culture to culture. Research performed in just one type of culture, such as WEIRD cultures, are not reflective of the human species as a whole.

Within Western culture, there are substantial individual differences in children's sensitivity to social cues and ability to respond in a contextually-appropriate manner. The aim of Chapters Two and Three were to test individual variation in early sensitivity to and response to social cues with regard to two common sources of individual variation: temperament and autistic traits.

Temperament

Temperament can be understood as variation in reactivity and self-regulation that are generally stable over time (Rothbart, Ahadi, & Hershey, 1994), and is comprised of such things as an individual's attention, sociability, activity level, and mood control. Differences in temperament can impact how children perceive and respond to their environment (Escalona, 1968; Rothbart et al., 1994) and their overall social competence (Dollar & Stifter, 2012; Eisenberg, Fabes, Guthrie, & Reiser, 2000; Rubin, Burgess, & Hastings, 2002). For example, children placed in identical situations, such as interacting with a stranger, will respond differently based on temperamental reactivity (Escalona, 1968). This can also lead to differences in reaction to social reinforcements (Gray, 1981) that impact how children learn from social situations and environments (Rothbart et al., 1994), and how the brain responds to viewing social stimuli (i.e., amygdala's response to happy faces, Canli, Sivers, Whitfield, Gotlib, &

Gabrieli, 2002).

In particular, an individual's level of temperament is interconnected with social situations. Extroversion, one aspect of temperament, includes an individual's desire and tendency to interact and be around others, and in early childhood is referred to as its precursor, surgency (Rothbart, Derryberry, & Hershey, 2000). It has been posited that those with higher levels of extroversion either desire social interactions more than others, or are more rewarded by these interactions (see Smillie, 2013, for review). This increased motivation to engage in social interactions can impact how children attend, and respond, to cues during social interactions, and as such was the focus of Chapter Two's investigation of temperamental differences in response to social cues.

Autism Spectrum Disorder

Much of the past research on impaired social functioning has focused on clinically significant levels of impairments, such as those seen in individuals with ASD. A diagnosis of ASD is in part characterized by deficits in social communication, and one area of social communication that is particularly challenging for children with ASD is nonverbal sensitivity. Nonverbal sensitivity refers to aspects of nonverbal social communication such as interpretation of facial expression, eye gaze, body posture, gestures, and prosody (Ingersoll, 2009). Though ASD is a clinical diagnosis, ASD is increasingly being viewed not as a spectrum separate from the general population but rather as the extreme end of continuous distribution of social and communication ability in the general population (Baron-Cohen, 1995; Constantino & Todd, 2003; Frith, 1991; Posserud, Lundervold, & Gillberg, 2006; Wing, 1981, 1988). As such, autistic traits are distributed within the general population (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001), with estimates of the prevalence of autistic traits ranging from 10–40% of individuals displaying low levels, and 1–2% reporting high levels (Constantino & Todd, 2003; Nordin & Gillberg, 1996). These sub-clinical levels of autistic traits are thought to be generally stable over time (Robinson et al., 2011).

Even without clinically significant levels of autistic traits leading to a diagnosis of ASD, these features can impact typically developing individuals' social functioning (Ingersoll, 2009; Jobe & Williams White, 2007). Autistic traits make the task of attending to the social environment, interpreting social cues, and using context to inform behavior quite difficult. Ingersoll (2009) examined the relationship between levels of autistic traits and nonverbal sensitivity in a sample of neurotypical college students. Those who scored higher on the Autism Spectrum Quotient (AQ; Baron-Cohen et al., 2001), a measure of autistic traits in individuals with ASD and the general population, displayed decreased knowledge of nonverbal cues and increased difficulty interpreting facial expressions. Similarly, on a test measuring social sensitivity, there was an inverse correlation between level of autistic traits and performance on the task, such that those with higher levels of autistic traits displayed decreased social sensitivity (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001). While these traits don't necessarily indicate severe impairment in social communication, they can provide additional information about the variability present in social communication ability.

Aims

In order to understand the role of individual variation in response to cues, the aim of this research was to investigate whether individual differences in children influence their response to lower level sensory cues (Chapter One) and higher level social cues (Chapter Two), and whether this variation guides the completion of social behaviors (Chapter Three).

In Chapter One, caregivers of infants at a high and low risk for ASD, and teenagers with and without ASD, completed the Sensory Profile questionnaire (Infant/Toddler Sensory Profile, Dunn, 2002; Adolescent/Adult Sensory Profile, Brown & Dunn, 2002) to assess their response to sensory cues in the environment. We predicted that high-risk infants and teenagers with ASD would endorse unusual sensory behaviors in response to sensory cues at a higher level than low-risk infants and teenagers without ASD.

In Chapter Two, children participated in a social learning paradigm as a way to measure level of social engagement with an experimenter. Children were assessed on whether their scores on the Early Childhood Behavior Questionnaire-Very Short Form (ECBQ-Very Short; Putnam, Jacobs, Garstein, & Rothbart, 2010) temperament scale were predictive of their responses to an experimenter who displayed positive social cues (i.e., smiling and high pitch, high prosody vocalizations) or negative social cues (i.e., neutral affect and low pitch, low prosody vocalizations). According to past research on temperament (Fenstermacher & Saudino, 2016; Hilbrink, Sakkalou, Ellis-Davies, Fowler, & Gattis, 2013; McCall et al., 1977), we predicted that children with higher levels of surgency would be more likely to display social engagement (e.g., eye contact, imitation) when the experimenter displayed positive social cues rather than negative social cues.

In Chapter Three, children were tested on whether individual differences in sensitivity and ability to correctly interpret social cues (as measured by levels of autistic traits) were associated with use of social cues to guide behavior. While most typically developing children will reliably use social cues to guide their behavior, we predicted that children displaying higher levels of autistic traits would be less likely to use social cues to guide their behavior. Together, these studies addressed variation in response and interpretation of cues as mediated by individual differences in temperament and by characteristics of, and risk for, ASD. The accurate interpretation of sensory and social cues, and the culturally-appropriate response to these cues, is essential for optimal daily functioning.

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1 Differential patterns of unusual sensory behaviors in infants at risk for, and teenagers with, Autism Spectrum Disorder

Abstract

The current study investigated the prevalence and pattern of unusual sensory behaviors (USBs) in teens with Autism Spectrum Disorder (ASD) and infants (ages 3 – 36 months) at risk for ASD. From two different sites (UCSD and UConn), caregivers of infants at high (n = 32) and low risk (n = 33) for ASD, and teenagers with (n = 12) and without ASD (n = 11), completed the Sensory Profile questionnaire (Infant/Toddler Sensory Profile, Dunn, 2002; Adolescent/Adult Sensory Profile, Brown & Dunn, 2002). The results show that high-risk infants and teenagers with ASD exhibit a higher–than-typical prevalence of USBs. The results of our pattern analyses investigating the type of atypicalities, (i.e., greater–than–typical vs. less–than–typical) revealed a fair degree of consistency across teens, which was more varied for high-risk infants.

1.1 Introduction

Autism Spectrum Disorder (ASD) is characterized by the presence of social communication deficits as well as restricted and repetitive behaviors (DSM-5; American Psychiatric Association, 2013). It has long been known since ASD was first described in the 1940's (Asperger, 1944; Kanner, 1943) that unusual sensory behaviors (USBs; i.e., increased prevalence of sensory atypicalities) are a common feature of the disorder, which has been incorporated into the DSM-5. Since USBs are now used as a diagnostic tool for identifying ASD early in life, and because of their profound impact on those affected, it is crucial that we develop a more comprehensive understanding of the emergence of USBs early in development. The current study investigated USBs in young infants who are at risk for developing ASD (younger siblings of children diagnosed with ASD), with the notion that these infants carry some of the genes associated with ASD and therefore may exhibit USBs that will help us better understand early risk factors in ASD.

Results from several previous studies have shown that USBs are highly prevalent in ASD, with estimates ranging from 45% to 95% of individuals with ASD demonstrating some level of USBs (Baker, Lane, Angley, & Young, 2008; Baranek, David, Poe, Stone, & Watson, 2006; Kay, 2001; Tomchek & Dunn, 2007). These behaviors have been shown to occur in the auditory, tactile, visual, and oral domains (Kern et al., 2007). In a meta-analysis by Ben-Sasson and colleagues (2009), 14 studies were examined that investigated USBs in individuals with ASD. They classified sensory behaviors in these studies according to three categories: (1) under-responsivity, which refers to indifference or slow response to sensory input, (2) over-responsivity, which refers to exaggerated or prolonged reaction to sensory input, and (3) seeking, which refers to intense desire or interest in sensory experiences. Results indicated that individuals with ASD differed from typically-developing controls in all three aspects of sensory processing examined: under-responsivity, over-responsivity, and sensation seeking, with the strongest difference being in under-responsivity.

Of the studies reviewed by Ben-Sasson et al. (2009), 79% used a version of a questionnaire called the "Sensory Profile" (Dunn, 1999a; Infant/Toddler Sensory Profile (ITSP), Dunn, 2002; Short Sensory Profile, Dunn, 1999b). The Sensory Profile examines the frequency of USBs by characterizing two dimensions of sensory behaviors: (1) an individual's neurological sensitivity, which refers to the sensitivity of relatively low-level sensory systems, and can be classified as low versus high, and (2) reactivity, which refers to how an individual responds behaviorally to sensory stimuli, and can be classified as passive versus active. Based on this model (Dunn, 1997), sensory behaviors can be classified according to four categories of sensory responsiveness: Low Registration (i.e., low sensitivity and passive response), Sensation Seeking (i.e., low sensitivity and active response), Sensory Sensitivity (i.e., high sensitivity and passive response), and Sensation Avoiding (i.e., high sensitivity and active response) (see Figure 1.1 for examples). Additionally, questions on the Sensory Profile are separated based on the perceptual modality in which these behaviors occur (e.g., Auditory, Visual, Tactile, Vestibular, Oral). Responses are then examined based on their deviation from reported norms, leading to a specific sensory profile for each individual.

It is important to point out that in individuals with ASD, USBs can manifest as either occurring at a higher or lower frequency than those seen among typically developing individuals. For example, in response to a statement such as "My child is unaware of people coming in and going out of a room" (ITSP; Dunn, 2002), one would expect this to be true some of the time in a typically developing child. If a child is always unaware, then that may be indicative of atypical processing. On a similar note, if a child is never unaware, this would also be indicative of atypical processing.

Additionally, contradictory patterns of sensory responsiveness can co-occur in the same individual, across different sensory modalities (Dunn, 1997). For example, an individual might be hyper-aware of certain visual stimuli and under-aware of certain auditory stimuli.

When examining USBs in ASD across development, there is no clear consensus as to how, or if, they change with time. The meta-analysis of Ben-Sasson et al. (2009) suggested a steady increase in the frequency of USBs in children with ASD until 9 years of age, and then subsequently decreasing. In contrast, McCormick, Hepburn, Young, and Rogers (2016) found no change in the trajectory of USBs in a longitudinal study following children with ASD from 2 to 8 years of age. Using the Sensory Profile (Dunn, 1999a), Lidstone et al. (2014) found a decrease in Sensory Seeking behaviors in children with ASD between 3 and 17 years of age.

Other studies have restricted their comparison of USBs between individuals with ASD and typically developing controls to the teenage years. In one study, De la Marche, Steyaert, and Noens (2012) obtained self-reported sensory behaviors in 80 adolescents with ASD using the Adolescent/Adult Sensory Profile (AASP; Brown & Dunn, 2002). In comparison to controls, adolescents with ASD exhibited atypically low frequencies of USBs in the Sensation Seeking domain, and atypically high frequencies of USBs in the Sensation Avoiding domain. The authors concluded that these combined effects suggest different ways in which adolescents with ASD seek to minimize sensory input. In another study of 25 adolescents, Stewart et al. (2015) corroborated the findings of atypically low frequencies of USBs in Sensation Seeking in ASD (compared to typically developing controls), however, unlike De la Marche et al. (2012), this study reported atypically high frequencies of Low Registration behaviors. Finally, in a study of 14 adolescents with ASD, Howe and Stagg (2016) reported that all participants experienced USBs (i.e., scoring outside the established normal range published by Dunn and colleagues) in at least one quadrant on the AASP, with 86% of individuals indicating USBs in two or more quadrants. When examining the data closer, the majority of adolescents who indicated USBs reported an atypically high frequency of Low Registration, Sensory Sensitivity, and Sensation Avoiding behaviors and an atypically low frequency of Sensation Seeking behaviors. In sum, despite inconsistencies in the exact nature and developmental course of USBs, there is consensus regarding the occurrence of USBs in early childhood and their continuation into adolescence in individuals with ASD.

But what about USBs in the first few months of life? Since ASD is not diagnosed reliably before 24 months of age (Cox et al., 1999; Lord, 1995; Stone et al., 1999), it is difficult to discover the symptoms of ASD in early infancy. One approach to this challenge has been to study early videos of children later diagnosed with ASD and/or rely on retrospective reports of early life from their parents. However, this approach is potentially limited by lack of experimental control and/or parental bias. A second approach involves examining infant siblings of children diagnosed with ASD. These siblings are referred to as high-risk infants, as they have a greater likelihood of developing ASD (˜20%, Ozonoff et al., 2011) than that seen in the general population (˜1.5%, Centers for Disease Control and Prevention, 2014). Using this prospective approach, high-risk infants are compared to low-risk controls (defined as infants without a family history of ASD) on a particular behavior early in development. These data can then be examined in two ways. Researchers may wait until ASD can reliably be diagnosed (between 24 and 36 months), and then examine differences between infants who developed ASD versus those who did not develop ASD. Results using this approach indicate the presence of early social, communication, and language deficits in infants who later developed ASD (e.g., see Jones, Gliga, Bedford, Charman, & Johnson, 2014, Rogers, 2009, and Zwaigenbaum et al., 2009, for reviews). Alternatively, researchers may focus on differences that are seen between high-risk and low-risk infants, regardless of a potential future ASD diagnosis. This method provides information about the broader autism phenotype, i.e., behavioral markers of ASD that are seen in unaffected relatives of those with ASD. Using this method, results indicate that high-risk siblings who do not develop ASD nevertheless demonstrate low levels of autism symptomology as well as other delays in development (e.g., Charman et al., 2016, Messinger et al., 2013).

Most relevant to the current study, there have been multiple studies investigating USBs in high-risk infants, using observational measures, parent interviews, or parent questionnaires. In a study that used a semi-structured interview, Sacrey et al. (2015) asked caregivers about developmental concerns across a variety of domains. Parents of high-risk infants who later developed ASD reported more sensory concerns than those of high-risk infants who did not develop ASD and low-risk infants. In another study that used an in-lab object exploration task, Ozonoff et al. (2008) reported that, on average, high-risk infants who went on to develop ASD exhibited more visual exploration of objects than high-risk infants who did not develop ASD, high-risk infants who developed a developmental delay, and low-risk control infants. We have reported similar sensory differences in our past work comparing infants with and without the risk for ASD (Bhat, Galloway, & Landa, 2010; Kaur, Srinivasan, & Bhat, 2015). Infant siblings of children with ASD showed greater visual exploration of objects at 6 and 9 months and greater oral exploration of objects at 15 months compared to low-risk controls (Kaur et al., 2015). Using both observation and caregiver-report in case studies of nine high-risk infants who later went on to develop ASD, Bryson et al (2007) reported that all nine displayed unusual sensory or motor behaviors during their first three years of life. There is also evidence that some of these behaviors constitute a broader autism phenotype of ASD, seen even in high-risk infants who do not develop ASD. Specifically, during administration of the Autism Observational Scale for Infants (Bryson, Zwaigenbaum, McDermott, Rombough, & Brian, 2007) (at 18 months), Bryson et al. reported that both high-risk infants who did and did not go on to develop ASD put their hands to their ears more often than low-risk infants, suggestive of a type of auditory USB in this sample.

To date, two studies have compared USBs between high and low-risk infants by using the parent questionnaire called the Infant/Toddler Sensory Profile (ITSP; Dunn, 2002). Mulligan and White (2012) tested 13 high-risk infants between 11- and 13-months of age. As opposed to comparing their data with established norms on the ITSP, they compared their high-risk cohort to a low-risk cohort. This local control group of low-risk infants is preferable, since it can provide a better control for demographics such as geographical region and SES, which might also influence outcomes on the ITSP. In this study, high-risk infants (outcome diagnosis was unknown) were found to exhibit atypically low frequencies of Sensation Seeking behaviors. In another study, Germani et al. (2014) compared high- and low-risk infants at 24 months. They found that high-risk infants who later developed ASD differed from both the high-risk group that did not develop ASD and the low-risk group. Specifically, for both Low Registration and Auditory processing, high-risk infants who later developed ASD exhibited atypically high frequencies of USBs in these domains. Additionally, there was a non-significant trend for group differences in Sensation Seeking, with the high-risk infants who developed ASD indicating atypically high frequencies of these behaviors.

One limitation of both of these previous studies using the ITSP is that they collected data at only a single age (roughly 1 year, and 2 years, respectively). To get a more comprehensive look at USBs in infancy, the current study investigated the frequency of USBs in high-risk infants during the first three years of life by having parents complete the ITSP (Dunn, 2002) at multiple time points. For comparison, we also tested teens with ASD using the Adolescent/Adult Sensory Profile (AASP; Brown & Dunn, 2002). This allowed us to ask whether the frequency and types of USBs in high-risk infants differs from that observed in teenagers with ASD. While it is unknown which, if any, of our sample of high-risk infants later developed ASD, we hoped to gain information about the presence of sensory behaviors in the broader autism phenotype.

1.2 Method

Subjects. Teen subjects were recruited from the San Diego community. The sample consisted of 12 teens with ASD (3 females, 25%; M = 15.45 years, SD = 1.48) and 11 typically developing teens (TD; 5 females, 45.45%; M = 16.78 years, SD = 1.91; Table 1.1). Teens with ASD were diagnosed with ASD (Autistic Disorder, Aspergers Syndrome, or PDD-NOS) by a licensed clinical psychologist or medical doctor not associated with this research based on DSM-IV-TR criteria (American Psychiatric Association, 2013), and confirmed in the laboratory using the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000).

Infant subjects were recruited from two testing sites (University of California, San Diego (UCSD) and University of Connecticut-Storrs (UConn)). Subjects consisted of 32 (6 female, 18.75%) high-risk infants and for comparison, 33 (13 female, 39.39%) low-risk infants between the ages of 3 and 36 months (Table 1.2). Infants were classified as high-risk if they had an older sibling with a diagnosis of ASD (Autistic Disorder, Aspergers Syndrome, or Pervasive Developmental Disorder–Not Otherwise Specified, PDD-NOS), confirmed through the administration of the ADOS (Lord et al., 2000) and the Autism Diagnostic Interview–Revised (ADI-R; Lord, Rutter, & Couteur, 1994) by a licensed clinical psychologist, expert clinical judgment, and/or review of medical records, based on DSM-IV-TR criteria. Classification of high-risk infants was based on risk status, and outcome data regarding future diagnosis were not available. Infants were classified as low-risk if they had no immediate or extended family members with ASD. All low-risk infants also had an older sibling to better match the high-risk infants. Infants came in at multiple time points between 3 and 36 months of age. At each visit, they were given a cognitive assessment and parents were asked to fill out the ITSP (see below for exact time points). The study was approved by the Institutional Review Board at UCSD and UConn. Parents provided written, informed consent.

Cognitive Assessment. In teens, intelligence was assessed during their visit to the lab using the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999), which rendered a verbal IQ, performance IQ, and a full scale IQ (see Table 1.1). Two typically developing teens did not complete the WASI, but were included in future analyses. In infants, we used the Mullen Scales of Early Learning (MSEL; Mullen, 1995), which was administered by a trained experimenter, and evaluates cognitive/motor development (see Table 1.2). Although we conducted the MSEL each time an infant came in for the ITSP (see below for exact time points), because the number and months at which infants came in differed somewhat across infants and research sites, we decided to look at MSEL scores at months where we had the most data for both the high- and low-risk groups. To this end, we focused on data from 6, 8-9 and 14-15 months. All infants contributed data to at least one of these time points, with 22 high-risk (66%) and 18 low-risk (55%) infants contributing data to all three time points.

Sensory Profile Questionnaires. For teens, we used the AASP (Brown & Dunn, 2002), which is a self-report questionnaire of sensory processing in individuals aged 11 years and older. During a one-time visit to the lab, teenage subjects indicated how often they exhibit certain behaviors related to sensory experiences using a one through five scale, ranging from almost never (score of 1) to almost always (score of 5). Coding of the AASP is described below.

For infants, we used the ITSP (Dunn, 2002), which is a parent-report questionnaire of sensory behaviors in children from birth to 36 months of age. Parents filled out the ITSP during each visit to the lab. At UCSD, they were asked to come to the lab at 3, 6, 8, 10, 12, 14, 18, 24, and 36 months of age, whereas at UConn, parents were asked to come to the lab at 3, 6, 9, 12, 15, 18, and 24 months. They indicated how often their child exhibits certain behaviors related to sensory experiences using a one through five scale, ranging from almost always (score of 1) to almost never (score of 5). Note that the scoring of the ITSP is the opposite of the AASP scoring, with higher scores on the ITSP indicative of atypically low frequency of a behavior, and lower scores indicative of atypically high frequency of a behavior. Thus for presentation purposes and to be consistent with the scoring of the AASP, we reverse scored the ITSP data, such that a higher score referred to atypically high frequency of behaviors and a lower score referred to atypically low frequency of behaviors. This reverse scoring system for the ITSP will be used throughout the rest of the paper. Two different versions of the ITSP were used, dependent on if the child was between birth and 6 months of age, or between 7 and 36 months of age. Questions vary slightly between the two versions to reflect appropriate developmental activities and milestones. Coding of the ITSP is described below.

Coding of the Questionnaires. The AASP used in adolescents examines four different quadrants of sensory processing: Low Registration, Sensation Seeking, Sensory Sensitivity, and Sensation Avoiding. For the different quadrants, the AASP has been normed, such that each subject (for each quadrant) received one of five possible scores (much less than others, less than others, typical, more than others and much more than others), which we assigned numerically as -2, -1, 0, 1, and 2. Scores of -2 and -1 were categorized as atypically low frequencies, scores of 1 and 2 were categorized as atypically high frequencies, and 0 was categorized as typical. As the AASP does not categorize responses according to individual perceptual domains (such as auditory, visual, tactile, etc.), the perceptual domain analysis was not performed.

Like the AASP, the ITSP examines four different quadrants of sensory responsiveness: Low Registration, Sensation Seeking, Sensory Sensitivity, and Sensation Avoiding. Separately, responses are categorized into different perceptual domains: Auditory, Visual, Tactile, Vestibular, and Oral, which were used for the perceptual domain analyses. Like the AASP for teens, the ITSP has been normed (for both the quadrants, and the perceptual domains), such that scores of -2 and -1 were categorized as atypically low frequencies, scores of 1 and 2 were categorized as atypically high frequencies, and 0 was categorized as typical.

Categorization. It was our original goal to collect data from each of our 65 infants at each of our 9 time points (UCSD) or 8 time points (UConn), with the goal of analyzing ITSP data, separately at each time point. This proved to be problematic, for three reasons. First, the two research sites (UCSD and UConn) had independently been collecting ITSP data before we decided to combine our samples. Unfortunately, the time points were not exactly the same between sites. Second, as in any longitudinal study in infants, getting consistent compliance of parents is a challenge, and therefore some time points are missing for infants. A third related point is that some infants started the ITSP study later than others, and so, for those infants, we are missing earlier time points. As a result, we had insufficient numbers of infants at each time point to conduct a systematic study of the effects of age on our measure. We therefore came up with another method, which we believe is an effective way to characterize sensory atypicalities across age, which assesses whether an infant showed any evidence of a sensory atypicality.

Specifically, infants were considered as exhibiting a sensory atypicality if they were categorized as atypical at any time point, that is, if they had a non-0 score at any time point. This was done for each quadrant (in the quadrant analysis) and each perceptual domain (in the perceptual domain analysis). As such, each infant was categorized as either typical or atypical. We then further classified infants who were atypical into either atypically low or atypically high, as follows. We averaged their atypical scores for each quadrant and perceptual domain (i.e., -2, -1, +1, +2), leading to a final score for each quadrant and perceptual domain ranging from -2 to 2. For an infant who exhibited a sensory atypicality, their final categorization was atypically low if their average was less than 0, or atypically high if their average was greater than 0. For 6 instances, the average turned out to be 0. To be conservative, we excluded the individual data point from these subjects in analyses that categorized subjects into one of three categories (atypically low, typical, and atypically high), and only in the quadrant or perceptual domain in which the 0 average occurred. However, these data points were included in analyses that categorized subjects into one of two categories (atypical and typical), see below.

Analyses. Our analyses addressed two questions. First we asked whether the overall prevalence of sensory atypicalities differed between high- and low-risk infants, and between ASD and typical teens. For this analysis, we used two-category data (typical vs. atypical). For teens, the analysis was performed using a Pearsons Chi-Square analysis. As it was not expected that a high number of TD teens or low-risk infants would display sensory atypicalities, a Fisher's Exact test correction was used to control for the low expected count. As all significant results were consistent between the two tests, only the Fisher's Exact test results are reported. For infants, the analysis was performed using a Monte Carlo simulation, to address the fact that there were unequal number of time points between high- and low-risk infants (see below).

Second, we asked whether the distribution of data across three categories (atypically low, typical, and atypically high) differed between high- and low-risk infants and between ASD and TD teens. We addressed this using Chi-square and Fischer's Exact test. We describe each analysis, in turn, below.

Overall Prevalence of Atypicalities. To ask whether prevalence of sensory atypicalities differs between high- and low-risk infants, we not only compared our data between groups but also further analyzed the data using a Monte Carlo simulation. This is because there was an unequal number of subject time points between high- and low-risk infants. Specifically, high-risk infants contributed ITSP data at more time points (on average, 3.81) than did low-risk infants (on average, 2.58) and this difference was significant ($F(1{,}63) = 12.94$, $p < .001$; Table 1.2). This difference means that there were more opportunities for high-risk infants to be categorized as atypical, as any one time point with an atypical score would categorize the infant as atypical for that quadrant or perceptual domain, which could skew the results towards showing a greater prevalence of sensory atypicalities in high-risk infants.

We address this problem by employing a Monte Carlo simulation, which asks whether observed differences between groups in prevalence of sensory atypicalities is greater than that which would be predicted by chance. As a first step, each subject, at each time point, was assigned one of two values: typical (assigned a 0) or atypical (assigned a 1), with the latter disregarding whether the atypicality was atypically low versus atypically high. This yielded a table of 0s and 1s for time points and subjects, separately for high- and low-risk infants. As described above, an infant was categorized as atypical if they scored a non-0 at any time point, and categorized as typical if they scored only 0s across all of their time points. We then calculated the prevalence of atypical infants, separately for the high- and low-risk groups. We next computed the difference in prevalence between subject groups (i.e., high-risk prevalence – low-risk prevalence). We refer to this as the observed group difference in prevalence of atypicalities.

Then, the Monte Carlo simulation was performed by taking all the 0s and 1s in the table and randomly reassigning them, across the time points, subjects, and across group assignment. This simulation was repeated 10,000 times. For each simulation, we calculated the difference in prevalence between subject groups, leading to a distribution of differences that occur by chance. As a final step, we determined if the observed group difference was a value greater than 95% of the simulated values from the Monte Carlo. If so, this provides evidence of a significant difference in prevalence of sensory atypicalities between groups.

Distribution of Data Across Three Categories. To ask whether the distribution of categories differed between ASD and TD teens and between high- and low-risk infants we performed a Pearson Chi-square analysis with two groups (ASD/TD or high-risk/low-risk) and three categories (atypically low, typical, atypically high). This was performed for each quadrant (both teens and infants) and perceptual modality (infants only). As it was not expected that a high number of TD teens or low-risk infants would display atypicalities, a Fisher's Exact test correction was used to control for the low expected count. As all significant results were consistent between the two tests, only the Fisher's Exact test results are reported. Note that we could not perform a Monte Carlo simulation for these three-category data, since there is no obvious single observed group difference value to test in the model (as there was when we computed group difference in prevalence of atypicalities, above). We do not, however, expect the unequal time points between high- and low-risk infants to affect the three-category analysis, for two reasons. First, the results from the Monte Carlo simulation show that the observed group differences in prevalence of atypicalities is not due to unequal time points between high- and low-risk infants (see below). Second, the focus in this secondary analysis is on the distribution of the data across three categories, not on the prevalence of atypicalities. In other words, we are asking whether atypicalities are skewed towards atypically high vs. atypically low frequencies of behaviors.

1.3 Results

Cognitive Measures. For teens, there were no significant differences on the WASI (Table 1.1) between those with ASD and those typically developing. For infants, there was a difference between groups in the Early Learning Composite (ELC) and the Visual Reception subsection of the MSEL at the 14/15-month time point, and Fine Motor subsection at the 8/9- and 14/15-month time points, with high-risk infants performing lower than low-risk infants (Table 1.2). This is not surprising given similar results from previous studies showing underperformance by high-risk infants (Brian et al., 2014; Messinger et al., 2013; Ozonoff et al., 2014).

Overall Prevalence of Atypicalities. For teens, the results of a Fisher's Exact test indicated differences between ASD and typically developing teens in some (but not all) quadrants (Figure 1.2). Specifically, the prevalence of atypicalities was greater in ASD teens for Sensation Seeking (67% vs. 18%, $p = .026$), and marginally significantly greater for Sensation Avoiding (58% vs. 18%, $p = .06$). As the AASP does not categorize responses according to perceptual domain, the perceptual analysis was not performed.

For infants, the results of the Monte Carlo simulation indicated that the observed group difference in prevalence of atypicalities was substantially (and significantly) higher than the simulated group difference in prevalence of atypicalities, for some (but not all) quadrants and some perceptual domains (Figures 1.3 & 1.4). Specifically, significant group differences were found for the Low Registration quadrant and the Tactile and Vestibular domains. In the Low Registration quadrant, the observed difference in prevalence was 35.7% (high-risk = 78.1%, low-risk = 42.4%), which was greater than 97.3% of the (10,000) simulated values, translating to a significant p value of 0.027. In the Tactile domain, the observed difference in prevalence was 27% (high-risk = 90.6%, low-risk = 63.6%), which was greater than 96% of the (10,000) simulated values, translating to a significant p value of 0.04. In the Vestibular domain, the observed difference in prevalence was 51.3% (high-risk = 93.8%, low-risk = 42.4%), which was greater than 99.7% of the (10,000) simulated values, translating to a significant p value of 0.003. In sum, a significantly increased prevalence of atypicalities was observed for high-risk infants in the Low Registration quadrant, and the Tactile and Vestibular domains. The finding of increased atypicalities in high-risk infants in the Low Registration domain differs from the atypicalities observed in teens with ASD (i.e., increased atypicalities in the Sensation Seeking domain), indicating the possibility of developmental changes in the nature of sensory atypicalities over time.

Distribution of Data Across Three Categories. For this analysis, we wanted to know, given there is an increased prevalence of atypicalities for a group, whether the atypicalities are more skewed towards atypically low, or atypically high, frequencies of sensory behaviors. Additionally, we wanted to know if there were group differences in the types of atypicalities between groups that were not revealed in the prevalence of sensory atypicalities analyses. For teens, there were group differences in this distribution analysis in three of the four quadrants, two of which also showed increased overall prevalence of atypicalities (see above) (Figure 1.5). Specifically, we observed a group difference in the Sensation Seeking quadrant ($p = 0.033$), which appears to be driven by a high percentage of teens with ASD (58%) indicating atypically low frequencies of sensory behaviors, which was not seen in typically developing teens (9%). Further examination showed that all but one ASD teen who exhibited an atypicality endorsed atypically low frequency of behavior, meaning that the direction of atypicality is quite homogeneous. For the Sensation Avoiding quadrant, we observed a group difference (which was marginally significant, $p = .084$), which appears to be driven by a high percentage of teens with ASD (50%) indicating atypically high frequencies of sensory behaviors, which was not seen in typically developing teens (9%). Further examination showed that all but one ASD teen who exhibited an atypicality endorsed atypically high frequency of behavior, meaning that the direction of atypicality is quite homogeneous.

Although Low Registration did not reveal group differences in the overall prevalence of atypicalities (above), in this distribution analysis, we observed a group difference ($p = .024$), which appeared to be driven by a high percentage of teens with ASD (58%) indicating atypically high frequencies of sensory behaviors, which was not seen in typically developing teens (9%). Further examination showed that all ASD teens who exhibited an atypicality endorsed atypically high frequency of behavior, meaning that the direction of atypicality is quite homogeneous.

For infants, we observed significant group differences in the distribution analysis in five of the nine categories, three of which also showed increased overall prevalence of atypicalities (see above) (Figures 1.6 & 1.7). Specifically, we observed a group difference in the Low Registration quadrant ($p = .013$), which appears to be driven by a low percentage of high-risk infants (22%) with typical frequencies of sensory behaviors, with roughly equal percentages of atypically high and atypically low sensory behaviors, while the low-risk group showed a high percentage of infants with typical frequencies (58%). For the Tactile domain, we observed a group difference (p $<.0001$), which appears to be driven by a high percentage of high-risk infants (81%) indicating atypically high frequencies of sensory behaviors, which was not seen in low-risk infants (21%). For the Vestibular domain, we observed a group difference ($p = .0001$), which appears to be driven by a high percentage of high-risk infants (73%) with atypically low frequencies of sensory behaviors, which was not seen in low-risk infants (30%).

We also observed group differences in the distribution analysis in conditions that did not yield group differences in overall prevalence of atypicalities. For Sensation Avoiding and Auditory domains, we observed a group difference (p = .012 & p = .004, respectively), which in both cases, appears to be driven by a high percentage of high-risk infants (35% & 59%, for Sensation Avoiding and Auditory, respectively) with atypically high frequencies of sensory behaviors, which was not seen in low-risk infants (6% & 21%, for Sensation Avoiding and Auditory, respectively).

Further examination shows that for the Auditory, Tactile, and Vestibular perceptual domains, the direction of the atypicality (atypically low or atypically high) was quite homogenous. For both the Auditory and Tactile domains, all but three high-risk infants who exhibited an atypicality endorsed atypically high frequency of behavior. For the Vestibular domain, all but five high-risk infants who exhibited an atypicality endorsed atypically low frequency of behavior. This indicates that the direction of the atypicality was quite homogenous in the perceptual domains. In contrast, the Low Registration and Sensation Avoiding quadrants did not show homogeneity in the direction of the atypicality, with similar amounts of high-risk infants indicating atypically low and atypically high frequency of behavior.

1.4 Discussion

The purpose of this study was to examine USBs in teens with ASD and infants at high risk for developing ASD, with USB defined as atypical (with low or high) frequencies of sensory behaviors. In line with previous studies, (De la Marche et al., 2012; Howe & Stagg, 2016; Stewart et al., 2015) our results in ASD teens indicated significantly increased overall prevalence of USBs in the Low Registration and Sensation Seeking quadrants (and marginally significantly increased for Sensation

Avoiding). Interestingly, although our sample size was relatively low ($n = 12$), there was a large degree of homogeneity in the direction of the atypicality. Specifically, for Low Registration, all teens who showed a USB endorsed atypically high frequency of behavior. For example, in terms of Low Registration, teens with ASD are experiencing increased amounts of behaviors such as not noticing when people enter the room or when their name is being called. Likewise, for Sensation Seeking, all but one teen who showed a USB endorsed atypically low frequency of behavior. To give an example of what this means, for Sensation Seeking, teens with ASD are experiencing decreased amounts of behaviors such as attending events with loud music or engaging in physical activity. For Sensation Avoiding, all but one teen who showed a USB endorsed atypically high frequency of behavior. To give an example of what this means, for Sensation Avoiding, teens with ASD are experiencing increased amounts of behaviors such as staying away from crowds or moving away when others get close. The relative homogeneity seen in teens with ASD is in line with past research (De la Marche et al., 2012; Howe & Stagg, 2016; Stewart et al., 2015). However, the exact nature of the atypicalities, both which domains are impacted and the direction of the atypicalities, varies slightly from these studies.

Patterns of USBs in High-Risk Infants. While results from previous studies have suggested that high-risk infants may have USBs, to date there are very few direct tests. One way to examine this question is to use the ITSP. Prior to this study there were only two studies that used it, and over limited ranges (11-13 months, Mulligan & White, 2012; 24 months, Germani et al., 2014). Our study sought to improve upon past research through examining USBs not just at one time point, but rather at multiple time points across the first three years of life. In line with extant research in this area involving both parent-report and observational measures (Bryson et al., 2007; Germani et al., 2014; Loh et al., 2007; Mulligan & White, 2012; Ozonoff et al., 2008; Sacrey et al., 2015) we demonstrated the presence of increased USBs in the high-risk infants. Specifically, increased prevalence, and a different distribution, of USBs was observed in the Low Registration, Tactile, and Vestibular domains. Additional differences were found in the distribution of USBs in the Sensation Avoiding and Auditory domains.

While Mulligan and White (2012) found that 72% of high-risk infants (11 to 13 months) indicated USBs in the Sensation Seeking domain, and that overall, high-risk infants displayed atypically low frequencies of Sensation Seeking behaviors, our results indicated no difference between high-risk and low-risk infants in this domain. Mulligan and White (2012) explain their finding as potentially related to a lower capacity or motivation for infants to explore their environment. As we examined USBs in a broader age range of infants (3 to 36 months), our sample may have included children with more developed skills that allowed for increased capacity and motivation to explore, leading to a lack of observable differences in the Sensation Seeking domain.

Consistent with Germani et al. (2014) and Bryson et al. (2007) our data indicated differences in the Auditory processing domain. However, we additionally observed increased prevalence of USBs in the Tactile and Vestibular domains. Differences across studies in the domains in which USBs are present may be due to the different ages included in the analyses across studies. Future research that can sample ages more discreetly will be required to test this possibility directly.

Similar to teens with ASD, our data demonstrate relative homogeneity in some of the domains examined in the high-risk infants. Specifically, for the Auditory and Tactile perceptual domains, all but 3 infants who showed a USB endorsed atypically high frequency of behavior. For the Vestibular domain, all but 5 infants who showed a USB endorsed atypically low frequency of behavior. In contrast, no relative homogeneity was observed in the direction of atypicalities in the Low Registration and Sensation Avoiding quadrant domains. Being that the perceptual domains are comprised of questions drawn from the various quadrants, it is difficult to speak to the exact pattern of behaviors that are seen in the perceptual domains for our high-risk sample.

Our study is the first to date to explicitly examine if high-risk infants differ from low-risk infants in the distribution of USBs, not just the overall prevalence. While Germani et al. (2014) reported the mean scores for their sample, which indicated high-risk infants who later developed ASD as demonstrating higher frequency of sensory behaviors in the Low Registration and Auditory domains, they did not separate their sample by those who indicated atypically high versus atypically low frequency of sensory behaviors. As such, it is difficult to draw conclusions regarding the relative homogeneity and direction of the atypicality besides for what is intuited from the mean scores.

It is important to note that it is unknown which, if any, of the infants from our sample will develop ASD. As such, we cannot conclude if USBs are predictive of a later ASD diagnosis. However, due to the large effect size seen in our data, we do not think that the presence of USBs in high-risk infants are being driven solely by the subset of infants who may later develop ASD. Instead, we believe that our data provides evidence for the presence of USBs in the broader autism phenotype. Future studies should obtain outcome data to differentiate between those who do and do not develop ASD, as it is possible that those who develop ASD show an even higher prevalence of USBs which may shed insight on early risk factors for developing ASD.

Comparing USBs Across Development. Given that the broader autism phenotype (seen in high-risk infants) can be compared to individuals with ASD, differences observed between the high-risk infants and the ASD teens of the current study might provide insight into the development of USBs in ASD. We found that both teens with ASD and high-risk infants demonstrated different patterns of USBs in comparison to their respective control groups in Low Registration and Sensation Avoiding (trending in teens) quadrants, yet not in the other two quadrants (Sensation Seeking and Sensory Sensitivity). As such, these data suggest that the specific areas of sensory processing difficulties are somewhat consistent from infancy to adolescence. However, an interesting difference between infancy and adolescence is that, while the direction of atypicality is fairly homogeneous in teens for the quadrant analyses, the same was not observed for infants in the quadrant analyses. This suggests that some infants shift the direction of their atypicality as they get older. For example, in Sensation Avoiding, an infant might start out atypically high, e.g., frequently trying to escape from noisy environments, but later switch to atypically low, e.g., rarely trying to escape a noisy environment. Future studies that track individuals longitudinally will be required to examine this possibility. (NOTE: As the AASP does not separately examine the different perceptual domains, it is not possible to compare infants and teens along this dimension).

Limitations. As with most questionnaires, the AASP and ITSP are subjective in nature. Perhaps more importantly, parents' report on the ITSP may be biased based on their previous experience. Specifically, for a parent of a child with ASD who exhibits USBs, this bias could go in one of two (opposite) directions. On the one hand, due to their awareness of USBs, the parent may be more inclined to notice the presence of a USB in the younger (at risk) sibling. On the other hand, if the parent is making a judgment relative to the older child with a USB, they may underestimate the degree to which the younger (at risk) sibling exhibits USBs. Given that the current study found an increased prevalence of USBs in high-risk infants, we cannot rule out the possibility that greater awareness of USBs in parents of high-risk infants resulted in an inflation of the reporting of atypicalities in their infants. However, if this were the case, we would expect to find increased prevalence of USBs in high-risk infants in all dimensions, which we did not find. In the future, it would be interesting to examine whether USBs are reported to be more frequent in high-risk infants who do, vs. do not, have an older sibling who exhibits USBs, which might speak to the potential for parents previous experiences to bias their reports. Since we did not collect ITSP data from the older sibling, the current study cannot address this possibility.

Clinical Implications. These findings may have important implications for the broader autism phenotype and the need to monitor and possibly address USBs in high-risk infants who do not develop ASD in addition to those that do. Future studies should examine both the presence of USBs and frequency of sensory behaviors in high-risk infants who develop ASD as well as those who do not develop ASD to gain additional information about the relationship between ASD and sensory processing. While some clear patterns emerged regarding specific areas where sensory difficulties are most prevalent, it is important for therapists to speak to caregivers to understand the exact difficulties present in each individual. As the current data indicate, sensory differences vary widely in their manifestation (i.e., the frequency in which they occur) in high-risk infants. Therefore, it is especially vital to customize treatment plans, for each child, with the help of occupational therapists and/or speech therapists.

Chapter 1, in full, is currently under review for publication of the material in *Journal of Autism and Developmental Disorders.* Van Etten, H.M., Kaur, M., Srinivasan, S. M., Cohen, S. J., Bhat, A., & Dobkins, K.R. The thesis author was the primary investigator and author of this material.

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		Reaction	
		Active	**Passive**
Neurological Sensitivity	**High**	**Sensation Avoiding** *e.g. My child avoids contact with rough or cold surfaces (for example, squirms, aches, cries)*	**Sensory Sensitivity** *e.g. My child becomes agitated when having nails trimmed*
	Low	**Sensation Seeking** *e.g. My child enjoys looking at shiny objects*	**Low Registration** *e.g. My child takes a long time to respond, even to familiar voices*

Figure 1.1: Model of sensory processing. Examples taken from the Infant/Toddler Sensory Profile (ITSP, Dunn, 2002).

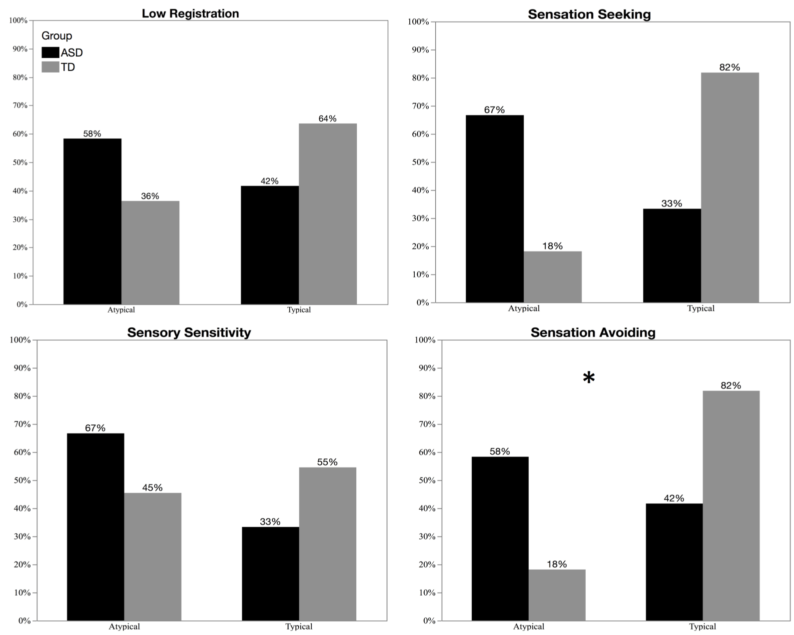

Figure 1.2: The prevalence of USBs in teens, by group, for each quadrant. *p<.05

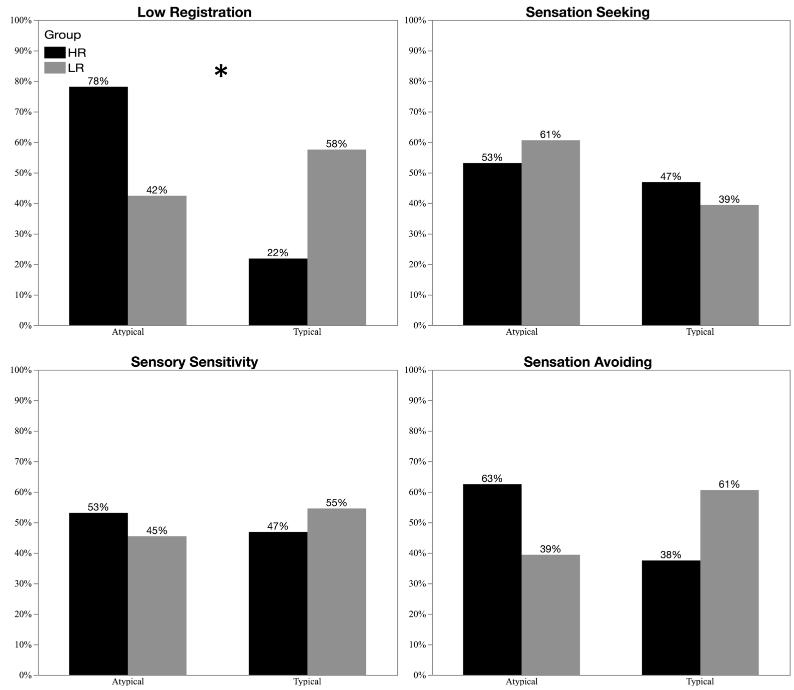

Figure 1.3: The prevalence of USBs in infants, by group, for each quadrant. *p<.05 in comparison to the Monte Carlo simulation

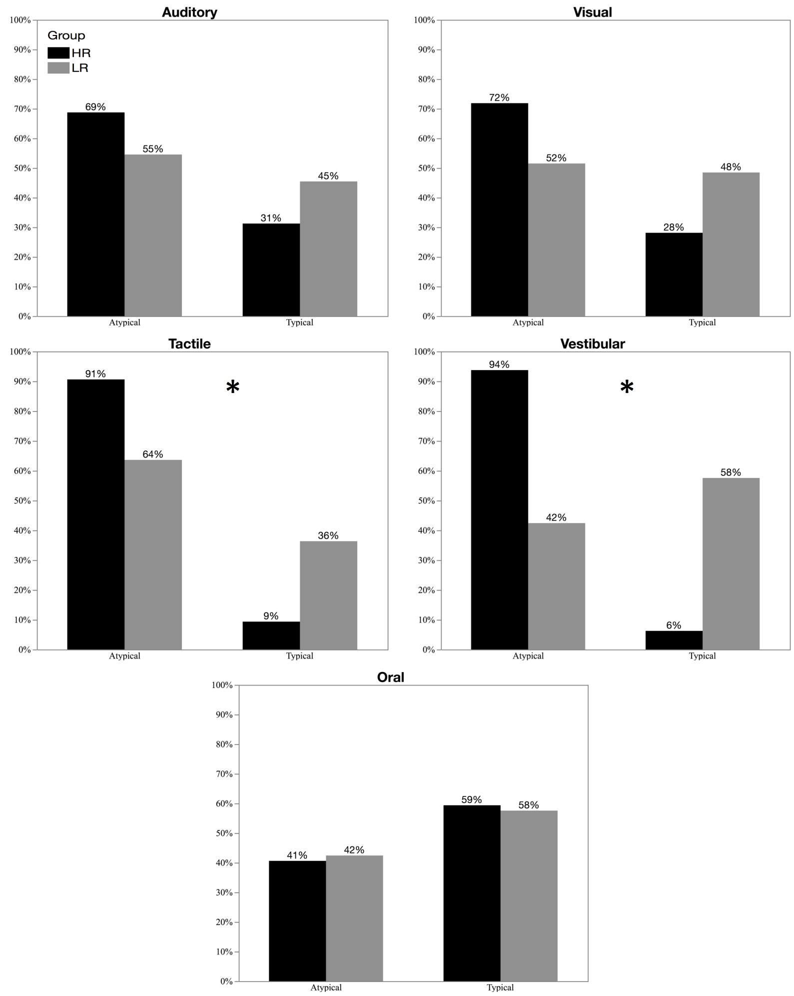

Figure 1.4: The prevalence of USBs in infants, by group, for each perceptual domain. *p<.05 in comparison to the Monte Carlo simulation

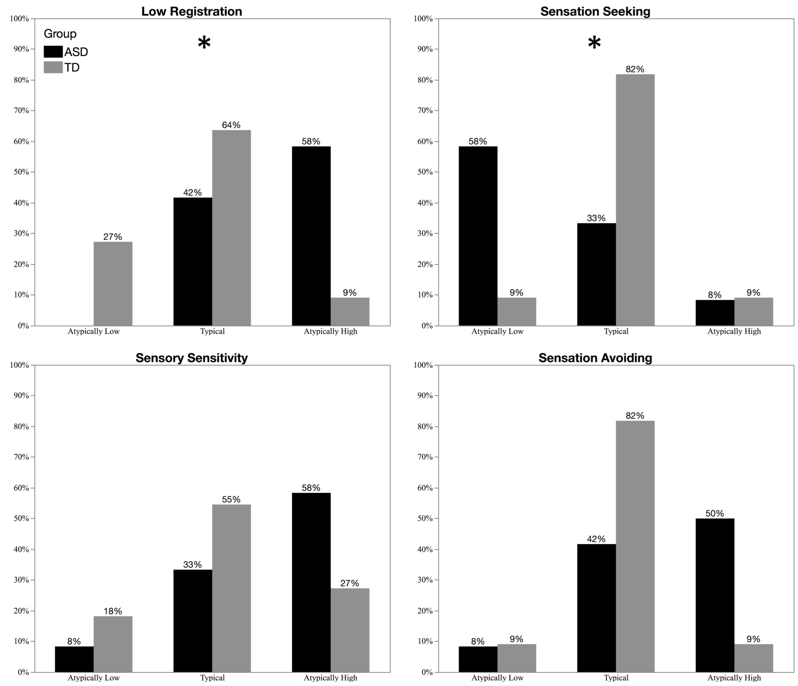

Figure 1.5: The distribution of USBs in teens, by group, for each quadrant. *p<.05

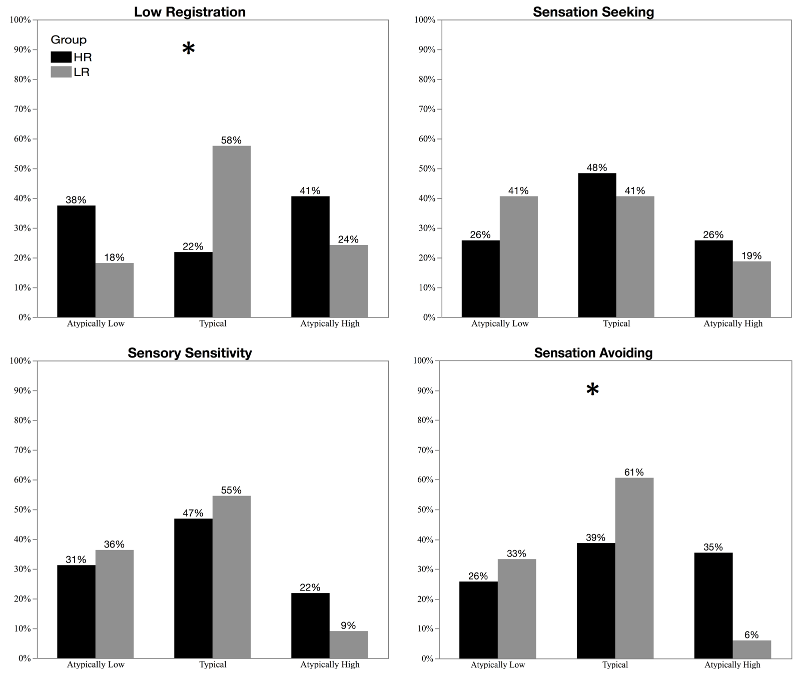

Figure 1.6: The distribution of USBs in infants, by group, for each quadrant. *p<.05

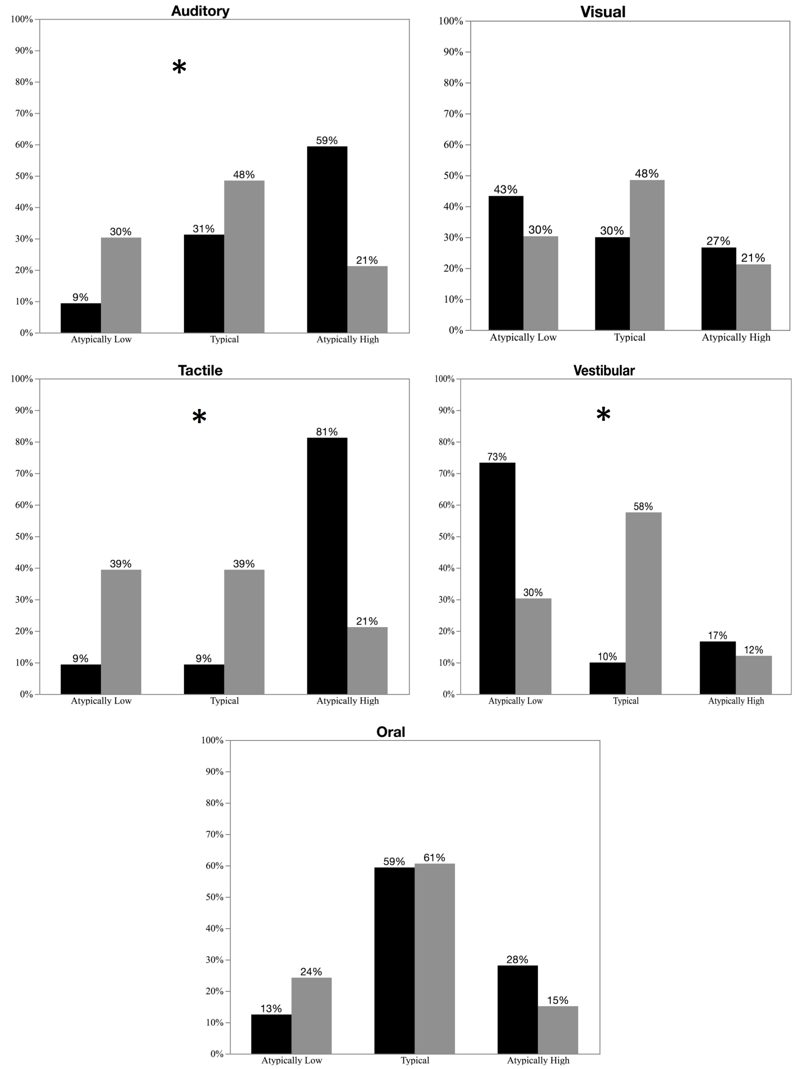

Figure 1.7: The distribution of USBs in infants, by group, for each perceptual domain. *p<.05

Table 1.1: Adolescent Demographic and WASI Data

	ASD (n = 12)			TD (n = 11)			Statistics
	Count		Percentage	Count		Percentage	
Gender	9 Male 3 Female		75 25	6 Male 5 Female		54.5 45.5	Fisher's Exact: p = .4
	Mean	SD	Range	Mean	SD	Range	
Age (years:months)	15:05	1:48	13:7-17:9	16:08	1:91	13:3-19:5	F(1,21) = 3.5, p = .07
Verbal IQ	97.5	22.1	55-127	113	16.1	92-138	F(1,19) = 3.15, p = .09
Performance IQ	102.7	15.1	82-129	111.1	9.6	93-124	F(1,19) = 2.15, p = .16
Full Scale IQ	100.4	19.1	67-132	113.7	13.3	99-132	F(1,19) = 3.15, p = .09

Table 1.2: Infant Demographic and MSEL Data

	High-Risk (n = 32)			Low-Risk (n = 33)			Statistics
	Count	Percentage		Count	Percentage		
Gender	26 Male 6 Female	81.25 18.75		20 Male 13 Female	60.61 39.39		Fisher's Exact: p = 0.1
	Mean	SD	Range	Mean	SD	Range	
Visits	3.81	1.73	2-7	2.58	0.94	2-6	F(1,64) = 12.94, p <.001
6 mo MSEL:	n = 27			n = 28			
Early Learning Composite	104	8.55	92-124	106	12.0	85-130	F(1,54) = 0.45, p = 0.51
Expressive Language	53	9.3	36-72	55	10.3	36-72	F(1,53) = 0.68, p = 0.41
Receptive Language	52	6.7	38-64	54	6.7	44-72	F(1,53) = 0.54, p = 0.46
Gross Motor	53	9.1	26-65	55	8.3	33-68	F(1,53) = 0.76, p = 0.39
Fine Motor	51	5.5	38-59	49	5.9	40-59	F(1,53) = 0.50, p = 0.48
Visual Reception	52	11.1	33-77	53	7.8	33-69	F(1,53) = .19, p = 0.67
8-9 mo MSEL:	n = 29			n = 30			
Early Learning Composite	106	12.4	83-132	109	15.2	83-139	F(1,58) = 1.1, p = 0.31
Expressive Language	50	10.1	29-76	53	10.3	35-71	F(1,56) = 0.74, p = 0.39
Receptive Language	49	8.4	34-66	52	8	39-70	F(1,56) = 1.8, p = 0.19
Gross Motor	48	10.3	21-72	50	7.4	36-68	F(1,56) = 0.58, p = 0.46
Fine Motor	55	9.2	44-72	60	9.2	38-79	F(1,56) = 5.0, p = 0.03
Visual Reception	55	8.9	33-68	56	11.3	33-80	F(1,56) = 0.04, p = 0.84
14-15 mo MSEL:	n = 26			n = 23			
Early Learning Composite	102	12.5	74-122	108	12.8	74-127	F(1,48) = 2.2, p = .14
Expressive Language	50	10.2	28-68	51	7.6	39-73	F(1,46) = 2.7, p = 0.11
Receptive Language	47	9.23	34-67	45	7.7	35-67	F(1,46) = 0.8, p = 0.37
Gross Motor	53	12	23-71	54	10.6	33-71	F(1,46) = 0.12, p = .73
Fine Motor	56	6.2	38-64	61	7.9	33-71	F(1,46) = 5.0, p = .03
Visual Reception	54	9.1	36-68	61	9.5	44-80	F(1,46) = 7.0, p = .01

2 Do temperament and social context impact social engagement in toddlers?

Abstract

From an early age, children are sensitive to social cues in their environment and use this information to modify their behavior. However, variation in individual temperament can play a role in how children respond to these cues. Eighteen to 24-month old toddlers were assessed on whether their scores on the Early Childhood Behavior Questionnaire-Very Short (Putnam, Jacobs, Garstein, & Rothbart, 2010) surgency subscale were predictive of their social responses to an experimenter who displayed positive or neutral social cues during an imitation paradigm. Toddlers varied in their eye gaze dependent on the facial and vocal affect of their partner, but no differences were observed dependent on temperament style or in their imitative behaviors. Understanding the interplay between individual temperament style and the impact of a partner's social characteristics is important for understanding what motivates toddlers to interact with and learn from others.

2.1 Introduction

Everyday interactions with social partners provide abundant learning opportunities for young children. During these interactions, a child's level of social engagement and learning can be influenced by different cues displayed by social partners, with children preferring to engage with social partners who interact contingently (Bigelow & Birch, 1999; Johnson, Slaughter, & Carey, 1998; Troseth, Saylor, & Archer, 2006) and display positive affect (e.g., smiling; Rotenberg et al., 2003). However, social learning is a bidirectional process and can also be impacted by variation within the child, such as from individual differences in temperament (e.g., Learmonth, Lamberth, & Rovee-Collier, 2005; Roberts, Wurtele, Boone, Metts, & Smith, 1981; Uzgiris, 1981). As past studies have not investigated the interplay of social engagement and temperament during social learning, the two aims of this study are to test whether individual differences in temperament affect children's use of social cues to: 1) guide social engagement, and 2) facilitate learning in an imitation task.

From a young age, children are attuned to socially relevant information and are able to use social cues, such as facial expression and eye contact, to guide their level of engagement with, and subsequent learning from, social partners. During a still-face paradigm in which caregivers cease interaction with their child and maintain a neutral expression (see Mesman, van IJzendoorn, & Bakermans-Kranenburg, 2009, for a review), infants as young as three months reliably respond by displaying increases in negative affect and decreases in social engagement (Abelkop & Frick, 2003; Kogan & Carter, 1996; Toda & Fogel, 1993; Yirmiya et al., 2006). By four months of age, infants are influenced by the contingency of an adult's interaction, preferring contingently responsive social partners to non-contingently responsive partners (Bigelow, MacLean, & MacDonald, 1996; Hains & Muir, 1996). By twelve months, infants use a partner's eye gaze to direct their attention to items of interest in the environment (joint attention, Carpenter, Nagell, Tomasello, Butterworth, & Moore, 1998). Additionally, when first learning about objects in the environment, toddlers use their caregivers' emotional expressions to inform their own behaviors towards a given object or situation (social referencing, Feinman, 1982; Moore & Corkum, 1994; Walden & Ogan, 1988).

Children also demonstrate a preference for contingently responsive individuals when learning. Nielsen (2006) manipulated the social engagement of a partner during an imitation paradigm. When the partner refrained from eye contact and busied themself with non-related tasks (i.e., reading a magazine) in between demonstrating novel actions, 18-month-old toddlers imitated fewer actions than those exposed to a socially engaging partner who demonstrated eye contact and was engaged throughout the session. However, this difference was not seen in 24-month-old toddlers. The lack of contingent responsiveness has also been theorized as underlying why children imitate less when exposed to a videotaped model than a live model (Nielsen, Simcock, & Jenkins, 2008). Broader characteristics of a social partner impact learning as well. For example, children will preferentially imitate social partners of the same gender (Cook & Smothergill, 1973) and more faithfully imitate those of similar cultural backgrounds (Buttelmann, Zmyj, Daum, & Carpenter, 2013; Wörmann, Holodynski, Kärtner, & Keller, 2012). They use a partner's history of reliability (Zmyj, Buttelmann, Carpenter, & Daum, 2010) and perceived intentions (Carpenter, Akhtar, & Tomasello, 1998; Meltzoff, 1995) when determining which actions to imitate and which actions to ignore.

Through attending to social cues during everyday interactions, infants and toddlers are able to acquire important information about their environments. However, children show distinct patterns of response to these cues even when placed in identical social situations, with variation due in part to differences in temperament. Temperament is comprised of patterns of reactivity and self-regulation that are generally stable over time (Rothbart, Ahadi, & Hershey, 1994; Rothbart & Derryberry, 1981) and includes behaviors such as attention, sociability, activity level, and mood control (Buss & Plomin, 1975; Goldsmith & Campos, 1982; Thomas & Chess, 1977). Most notably, temperament can impact how rewarding children find social situations (see Smillie, 2013 for a review), influencing the frequency with which children seek social engagement from others. Of the various facets of temperament, it is thought that extroversion (referred to as surgency in early childhood, Rothbart et al., 1994), or an individual's desire and tendency to interact with others, is most related to variation in social interaction, behavior, and learning (Dollar & Stifter, 2012; Fox et al., 1995; Rimm-Kaufman & Kagan, 2005; Rubin, Coplan, Fox, & Calkins, 1995).

When placed in novel environments, children low in surgency display wariness and anxiety (Coll, Kagan, & Reznick, 1984; Kagan, 1997), and in social situations tend to display shy and socially withdrawn behaviors (Burgess, Marshall, Rubin, & Fox, 2003; Kagan, Reznick, & Snidman, 1987; Kagan, Snidman, Zentner, & Peterson, 1999; Rubin, Burgess, & Hastings, 2002). These inhibited behaviors can negatively impact children's social learning opportunities with novel individuals, preventing them from obtaining new information. For example, McCall et al. (1977) found a modest positive correlation between extroversion and the tendency to imitate a live model in toddlers 18- to 36-months old. Hilbrink, Sakkalou, Ellis-Davies, Fowler, and Gattis (2013) measured levels of surgency in 15-month-old toddlers and imitation ability. Those with higher levels of surgency imitated the examiner more accurately than those with lower levels. In a recent study by Fenstermacher and Saudino (2016), 24-month-old toddlers who were rated by experimenters as more positive and socially outgoing in-lab were more likely to imitate the experimenter's actions. The relationship between imitation and extroversion has also been demonstrated in older children (i.e., 11-year-olds, Fouts, 1975), and has been hypothesized as relating to increased motivation as a result of the interpersonal nature of imitation (Hilbrink et al., 2013).

Past studies have either focused on how social learning and behavior are impacted by the characteristics of a social partner, or on how social learning and behavior is impacted by temperament. However, these two effects have not been investigated simultaneously. This is important to examine as individual variation can play a large role in the the interpretation and use of social cues, which are present during social learning. Therefore, the aim of this experiment was to examine how individual differences in surgency, an aspect of temperament, affect children's responses to one social cue — an individual's display of facial and vocal affect — during a social learning task (i.e., imitation). Specifically, this study used two between-subjects conditions to test the impact of an experimenter's display of positive and neutral facial and vocal affect on toddler's engagement (eye gaze, smiling, vocalizations) and learning (i.e., number of imitated actions). We expected that children's social engagement (i.e., social behaviors) would vary dependent on the social characteristics of their partner and the temperament style of the toddler, with toddlers demonstrating higher levels of surgency displaying more social behaviors in response to an experimenter displaying positive affect. Consistent with previous findings, we predicted that toddlers with higher levels of surgency would engage in more imitative actions than those with lower levels. We also predicted that imitated actions would be higher for those in the positive affect condition, and that this would be mediated by temperament style, specifically for those with higher levels of surgency. Understanding the interplay between individual temperament style and the impact of a partner's social characteristics is important for understanding what motivates toddlers to imitate.

2.2 Method

Participants. Participants consisted of 18- to 24-month-old toddlers recruited from a preexisting database of parents in San Diego County who expressed interest in participating in studies at the University of California, San Diego (UCSD) Department of Psychology. In total, 53 (M = 20.6 months, 27 male) toddlers participated, with an additional 6 subjects excluded due to fussiness ($n = 3$), experimenter error ($n = 2$), and language barrier ($n = 1$). Toddlers were randomly assigned to condition, leading to 26 toddlers in the positive condition and 27 toddlers in the neutral condition. Six participants did not fully complete the surgency questionnaire, and therefore were not included in analyses involving the surgency questionnaire. Of participants, 81.3% of parents reported their toddler as Caucasian, 4.2% as Filipino and Caucasian, 2.1% as Hispanic, 2.1% as Native American and Caucasian, 2.1% as Hispanic and Caucasian, 2.1% as Asian American/Pacific Islander and Caucasian, and the remaining 6.3% as mixed ethnicity. Regarding household income, 61.9% reported a combined household income of greater than $100,000, with the remaining 38.1% reporting incomes between $30,000 and $100,000. This study was approved by the Institutional Review Board at UCSD.

Materials. Three novel, wooden objects were used to measure imitation (Figure 2.1). Each of these objects had a series of three actions that could be executed. For all objects, the actions had to be performed in the predetermined order, as the second action could not be completed prior to the first, and the third action could not be completed prior to the second. These objects were designed such that it was not expected for a toddler to have interacted with the objects prior to the study. The order of the objects presented was randomized for each subject, and counterbalanced across conditions.

Measures. Parents completed the surgency subscale of the Early Childhood Behavior Questionnaire-Very Short Form (ECBQ-Very Short, Putnam et al., 2010) to assess infants' temperament. The ECBQ asks parents to rate their child's behaviors based on given situations on a 1 through 7 scale, with "1" indicating the behavior never occurs, and "7" indicating the behavior always occurs. The ECBQ does not provide established norms or interpretation of scores for the various aspects of temperament. However, a higher score in a given category is indicative of a higher frequency of behaviors related to that aspect of temperament. For surgency, the maximum score was an 84.

Procedure. Written, informed consent was obtained from the parent by a research assistant not involved in the experimental portion of the study. This was to ensure that toddlers were only exposed to the primary experimenter, and the predetermined level of affect, in which they were assigned to during the imitation paradigm. After consent, toddlers were accompanied to the testing room with their parent. Once there, they were greeted by the primary experimenter portraying either positive or neutral affect. In the positive affect condition, the experimenter maintained positive affect through smiling, speaking with a high intonation, and displaying positive facial expressions. In the neutral affect condition, the experimenter maintained neutral affect through limiting smiles, speaking with a flat intonation, and displaying neutral facial expressions.

To obtain a measure of prior ability, toddlers were given a novel wooden object and asked, "What can you do with this?" Toddlers had 20 seconds to begin exploring and interacting with the object. If the toddler was still exploring the object after 20 seconds had passed, they were given an additional 10 seconds to explore. To measure imitation ability, the experimenter took the object back and demonstrated the desired 3-step action twice with scripted narration (e.g., "Watch what I can do with this. I can find a horse. Watch how I find a horse. Pick it up. Push it in. Take it. Look. I found a horse."). After, the toddler was given the object and allowed to explore it for another 20 seconds. This was repeated for all three objects. This paradigm was adapted from a similar paradigm used to measure deferred imitation (Carver, 2011;

Carver & Bauer, 1999).

Coding. Three research assistants blind to experimental design and group assignment coded toddlers' behaviors based on the number of targeted actions (up to 3) per object that the toddler performed. These actions were examined both prior to the demonstration (pre) (to measure prior ability) and after the demonstration (post) (to measure imitation) of targeted actions. To examine imitation, the number of actions occurring pre–demonstration was subtracted from those that occurred post–demonstration, leading to an overall number of imitated actions (maximum of 9) for each child. Coders overlapped on 20% of subjects, with 96.67% reliability. Disagreements were resolved by consensus.

To measure social engagement, the frequency (i.e., number of occurrences) of toddlers' social behaviors — smiling, eye gaze, and vocalizations — were coded throughout the session. A smile was defined as the corners of the toddler's mouth being turned upward, with the mouth either open or closed. The frequency of smiling was coded irrespective of whether the behavior was directed towards the experimenter or towards the parent. Eye gaze was defined as any instance of the toddler looking at the experimenter or parent's face, regardless of if the experimenter or parent was looking back at them, and was classified as directed towards the experimenter or to the parent. All voluntary utterances were counted as vocalizations, and were further classified as whether they were directed to the parent or experimenter based on the orientation of the toddler's head and direction of eye gaze. Repeated utterances were counted as separate vocalizations if they occurred 1-2 seconds after the prior utterance. Additionally, the frequency of smiling behavior in responses to toddler's eye gaze was coded for a subset of parents ($n = 37$) as not all parents were in view of the camera. Coders overlapped on 20% of subjects, with 90.28% reliability. Disagreements were resolved by consensus.

Analyses. To examine differences in social behaviors, a multiple regression was performed for each of the social behaviors (smiling, eye gaze, vocalization) directed both to the parent and to the experimenter with level of surgency, condition (neutral vs. positive; between subject) and age as predictor variables. The interaction between surgency and condition was also examined. To examine the effect of condition on imitated actions, a mixed effect model was performed with level of surgency (within-subject), condition (neutral vs. positive; between-subject), time (pre vs. post demonstration, within-subject), and age as predictor variables. The interaction between condition and time, and condition and surgency, was also examined.

2.3 Results

Toddlers in the neutral condition engaged in a higher frequency of eye gaze (M = 3.22, SD = 3.69) with their parents than toddlers in the positive condition (M = 1.5, SD = 1.79; $F(1{,}41) = 6.37$, $p = 0.016$, $\eta_p^2 = 0.17$; Figure 2.2). Post-hoc analyses indicated that, in response to initiation of eye gaze by the toddler, the frequency of parents' smiles did not differ by group ($t(37) = 0.26$, $p > 0.1$). There was a marginally significant interaction between level of surgency and condition on the frequency of vocalizations directed towards the experimenter ($F(1{,}41) = 3.12$, $p = 0.085$, $\eta_p^2 = 0.07$; Figure 2.3). As level of surgency increased in the positive condition, vocalizations increased. In contrast, as level of surgency increased in the neutral condition, vocalizations decreased. There was no effect or interaction between surgency and condition on the frequency of smiling, eye gaze directed to the examiner, or vocalizations directed to the parent (all ps > 0.1).

A significant effect of age was present on the frequency of vocalizations directed to the parent ($F(1{,}41) = 7.72$, $p < 0.01$, $\eta_p^2 = 0.18$), and a marginally significant effect of age on the frequency of smiling ($F(1{,}41) = 3.54$, $p = 0.067$, $\eta_p^2 = 0.07$) and eye gaze directed to the parent ($F(1,41) = 4.06$, $p = 0.051$, $\eta_p^2 = 0.13$; Figure 2.4). No effect of age was present for the frequency of vocalizations directed to the experimenter or eye gaze directed to the experimenter (all ps > 0.1).

There was an effect of time such that toddlers engaged in more actions after ($M = 4.85$, $SD = 2.69$) than before ($M = 1.11$, $SD = 1.10$) the demonstration ($F(1,44) = 102.75$, $p < 0.001$; Figure 2.3). There was no effect of age, condition, level of surgency, or interactions between the variables (all ps > 0.1).

2.4 Discussion

The purpose of this study was to examine whether differences in temperament (specifically, surgency) influence how toddlers respond to displays of positive and neutral affect during a social learning paradigm. In line with our predictions, there was an effect of social characteristics (i.e., affect) on toddler's social behaviors during the social learning paradigm. Toddlers in the neutral condition engaged in a higher frequency of eye gaze to their parents than toddlers in the positive condition. Adults in Western cultures typically use increased amounts of positive affect when engaging with toddlers (Keller, 2002a). Toddlers therefore may come to expect this form of interaction with adults and potentially be unsure how to react when presented with an adult expressing neutral affect. In this experiment, faced with the novel situation of a social partner with neutral affect, toddlers may have frequently referenced their parents to either seek comfort or to determine how best to react. The mere presence and availability of a parent may have ameliorated the potentially distressing situation of having a social partner who is not displaying positive affect, which would explain the lack of conditional differences in imitation. Future studies may benefit from removing the parent from the room to isolate the effect of the experimenter's affect from the comfort and familiarity of the parent's presence.

A marginally significant difference was observed in the frequency of social behaviors directed towards the experimenter. Toddlers with higher levels of surgency engaged in increased vocalizations towards the experimenter in the positive condition but decreased vocalizations in the neutral condition. When the experimenter displayed positive affect, toddlers with higher levels of surgency responded in the manner that was deemed most appropriate — by increasing their vocalizations to interact with an individual demonstrating positive social behaviors. When exposed to neutral affect, they again responded appropriately and engaged in decreased vocalizations in line with the social cues they were receiving. This may be a result of differences in social motivation, such that individuals with higher levels of surgency may be more motivated to engage socially with an individual displaying positive affect, as research demonstrates higher levels of surgency to be related to increased social motivation (Hilbrink et al., 2013; Smillie, 2013). However, more research needs to be performed before making conclusions as this difference was only marginally significant.

During the social learning paradigm, toddlers in both conditions, regardless of surgency, performed more actions after the demonstration than before, indicating that learning had occurred. This replicated years of past research exhibiting knowledge acquisition through imitation in children (e.g., Bauer, 1997; Meltzoff, 1988; Uzgiris, 1981). Contrary to expectations, no influence of affect (positive or neutral) or temperament on toddler's imitation behavior was observed. While no studies have examined emotional affect and imitation specifically, this was surprising given past findings by Nielsen (2006) that showed social engagement impacting imitation as well as studies showing an impact of temperament on imitation (Fenstermacher & Saudino, 2016; Hilbrink et al., 2013; McCall et al., 1977). One possible explanation as to why our data did not confirm these findings is due to variation in the types of actions demonstrated and subsequently imitated (i.e., necessary versus unnecessary actions). Nielsen (2006) found an effect of social engagement on imitation, but only in imitated actions that were viewed as unnecessary to obtaining the desired outcome (i.e., overimitation). Similarly, Hilbrink et al. (2013) found a relationship between surgency and the imitation of unnecessary actions. In contrast, our study examined immediate imitation, which involves the reproduction of actions, with all actions necessary for goal completion. We expected immediate imitation to be influenced by social characteristics because it mimics the reciprocal nature of typical social interactions (Nadel-Brulfert & Baudonniere, 1982) and serves a social purpose (in addition to knowledge acquisition; Uzgiris, 1981). However, it may be that instrumental imitation did not serve a strong enough social purpose and overimitation may be the only form of imitation impacted by these social characteristics. Future studies should examine the relationship between surgency, emotional affect, and imitation using overimitation. Understanding the interplay between imitation, social characteristics of a partner, and temperament could also be examined through comparing emotional affect and surgency during instances of overimitation versus immediate imitation. Additionally, it may be that the displays of positive and neutral affect used in this experiment were not salient enough to impact imitation in the manner we expected. Introducing a third variable of negative affect would be an interesting avenue to pursue, although caution would be needed as this level of affect may be distressing for toddlers.

This study examined how variation within a child, as measured by surgency, impacts responses to a social partner. However, in addition to variation within a child, it is important to also take into consideration that variation in cultural backgrounds and societal norms can play a large role in children's social behaviors. For example, imitation varies by context (conventional versus instrumental tasks) and culture (Clegg & Legare, 2016), influencing such things as the fidelity of imitation. Additionally, this study examined the impact that displays of positive and neutral affect had on children.

While engaging with a person displaying neutral affect may be a novel, and potentially uncomfortable, situation for children in Western societies, this is not necessarily true in societies where positive displays of affect are not emphasized (Akhtar & Gernsbacher, 2008; Keller, 2002a). As the sample used in this study came from a Western society and primarily consisted of Caucasian children from high socioeconomic status (SES) backgrounds, we are limited in the generalizability of our results to populations outside of the one sampled in this study.

One of the aims of this study was to examine if levels of surgency would impact how children learn from social partners who display either positive levels of affect or neutral levels of affect. To this end, we used a between-subjects design in which we randomly assigned children to level of affect. An alternate method of examining this question would be to first determine whether a toddler is high or low in surgency and then assign them to condition based on their level of surgency. Taking this approach is in line with literature suggesting an important role of goodness-of-fit, or match, between a child and their environment on cognitive and social outcomes (Churchill, 2003; Sanson, Hemphill, & Smart, 2004). This method would be an important next step to ascertaining the interplay between temperament, learning, and the social environment, which can have potential implications for children's long-term learning outcomes.

Chapter 2, in full, is currently in prep for publication of the material. Van Etten, H.M., & Carver, L.J. The thesis author was the primary investigator and author of this material.

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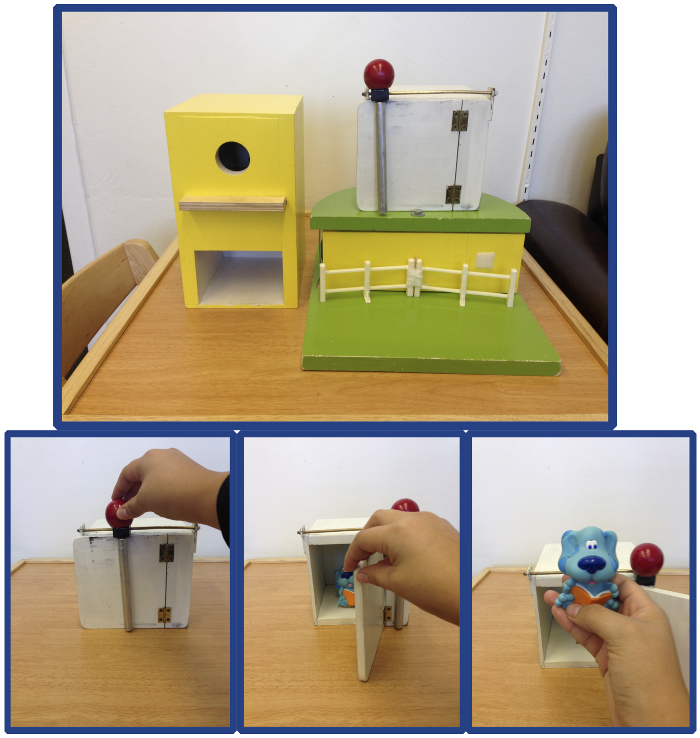

Figure 2.1: Stimuli used to measure imitation (top). Example sequence of actions (bottom).

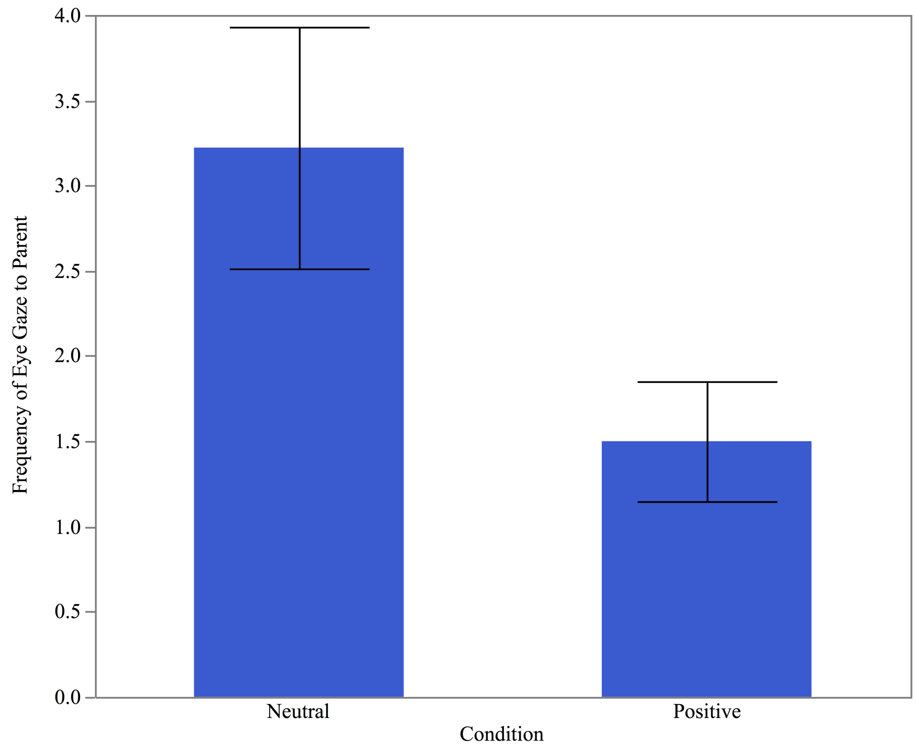

Figure 2.2: Frequency of eye gaze directed towards the parent by condition.

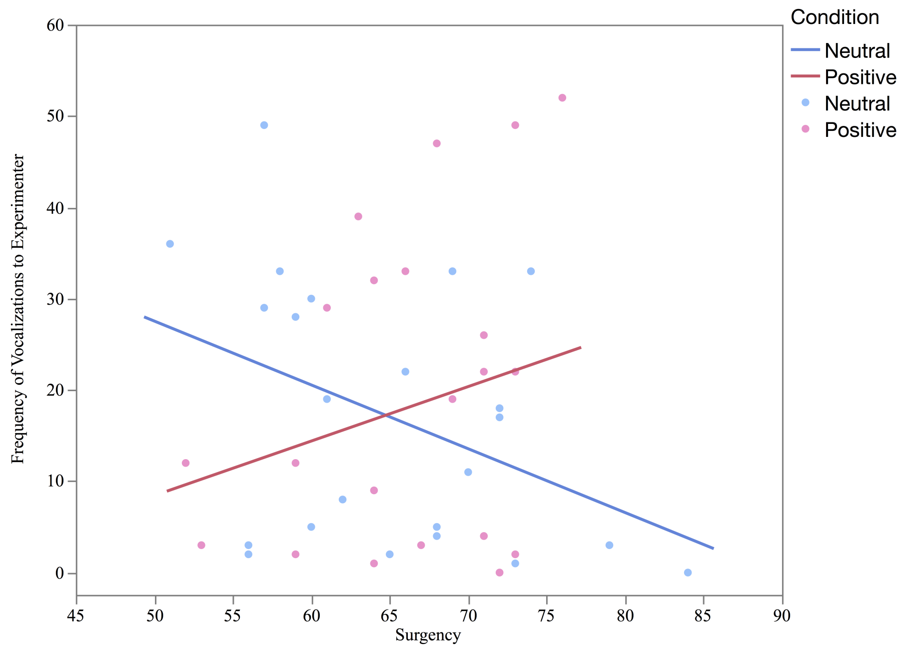

Figure 2.3: Interaction between condition and level of surgency on the frequency of vocalizations directed towards the experimenter.

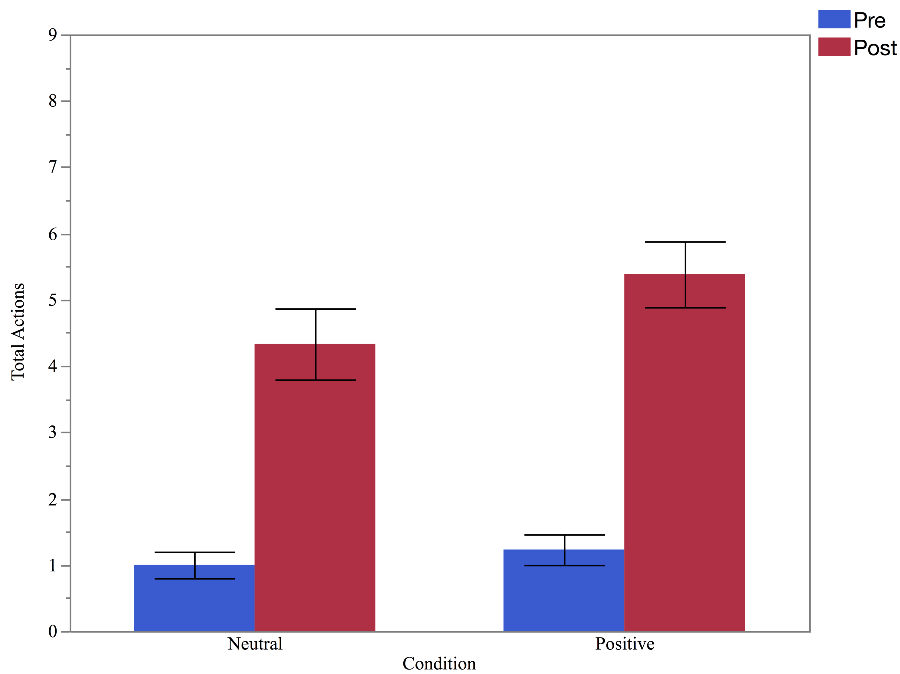

Figure 2.4: Number of imitated actions by group.

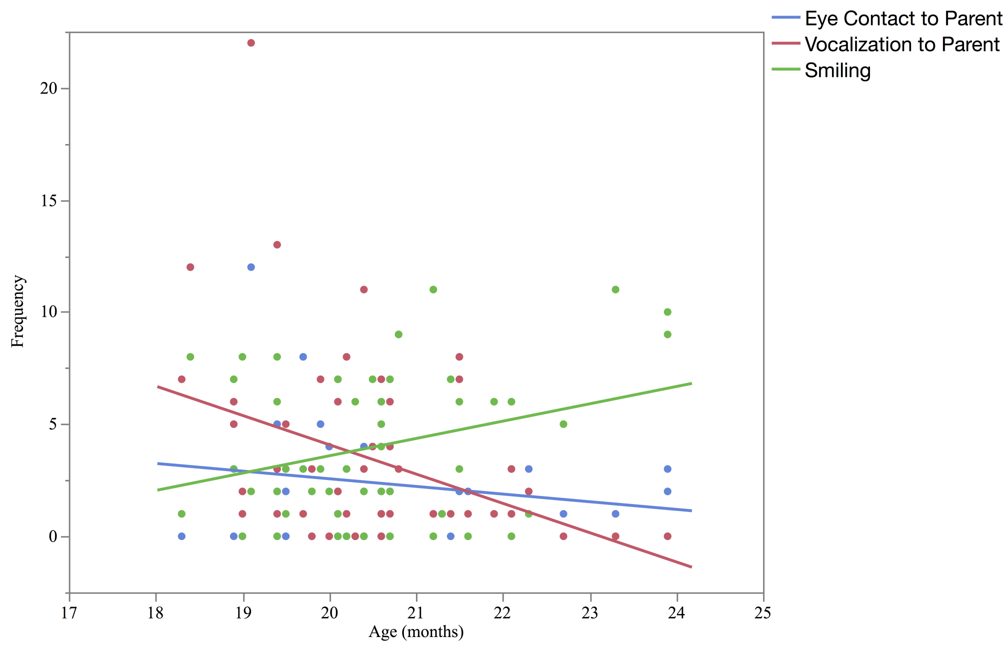

Figure 2.5: Effect of age on the frequency of social behaviors.

3 Knowing when to assist: An examination of the use of social cues to prompt prosocial behaviors in children with high levels of autistic traits

Abstract

The ability to engage in prosocial behaviors relies, in part, on understanding cues indicating that another individual is in need of assistance. However, children vary in the competency with which they are able to interpret these cues. The goal of this study was to examine if the presence of autistic traits in typically developing children negatively impacts their ability to use social cues to engage in prosocial behaviors. To examine this, parents completed questionnaires assessing their child's level of autistic traits and presence of prosocial behaviors. In lab, situations were contrived to give children the opportunity to engage in sharing, helping, and comforting behaviors. Based on parent report, children with higher levels of autistic traits were reported

as displaying decreased levels of prosocial behaviors, but this difference was not seen in-lab. No relationship was observed between autistic traits and the use of social cues.

3.1 Introduction

As part of a cohesive society, individuals engage in behaviors that are for the betterment of others. Such prosocial behaviors are characterized as being performed without an explicit benefit to the individual doing the behavior, and include behaviors such as helping, sharing, and comforting (Dunfield, 2014; Zahn-Waxler, Radke-Yarrow, Wagner, & Chapman, 1992). To engage in prosocial behaviors, one must: 1) recognize an individual is in need, 2) understand how to assist and have the necessary means to assist the individual in need, and 3) be motivated to assist the individual (Dunfield & Kuhlmeier, 2013). This can be a complex process that requires competency in many areas of social communication starting with an accurate interpretation of social cues — including understanding facial expressions and following eye gaze — as well as more advanced aspects of social cognition including Theory of Mind (see Imuta, Henry, Slaughter, Selcuk, & Ruffman, 2016 for a review). Interpreting the cues that indicate prosocial behaviors are needed can be difficult for some children, particularly those who demonstrate impairments in social communication (e.g., children with Autism Spectrum Disorder (ASD)). Therefore, the aim of this study was to examine how individual variation in social communication — as measured by levels of autistic traits — impacts the ability to use social cues to engage in three prosocial behaviors: sharing, helping, and comforting.

Various nonverbal cues can be used to infer that a situation warrants prosocial behaviors. For example, if an individual is trying to obtain an object that is out of reach, they may stretch their arm towards the desired object, and alternate their gaze between the object and the person who can be of assistance (i.e., to elicit helping). If hurt, an individual might display emotions of pain on their face and rub the hurt body part, while looking at a nearby person (i.e., to elicit comforting). Through identifying such cues as facial expression, eye gaze, and gestures, and subsequently interpreting this information, an individual can ascertain what prosocial behavior is warranted in a given situation. Accurately interpreting the cues provided when assessing the needs of others can be vital in determining not just if a prosocial behavior is warranted, but which behavior is needed (Dunfield, 2014).

Though correctly interpreting cues and using them to guide behavior can be quite complex, typically developing children are able to do so from a young age. Children as young as 18 months are able to identify situations in which an individual requires assistance and engage in helping and sharing behaviors in response (Dunfield, Kuhlmeier, O'Connell, & Kelley, 2011; Warneken & Tomasello, 2006, 2007; Zahn-Waxler et al., 1992). In one study examining children's helping behaviors, Warneken and Tomasello (2006) demonstrated that 18-month-olds were able to recognize and respond when the experimenter's behaviors indicated a need for help (e.g., reaching for an out-of-reach object) without the experimenter looking to them or verbalizing their need. Consistent with these findings, Dunfield et al. (2011) demonstrated that 18– and 24–month–olds engaged in helping and sharing behaviors when there were only subtle cues demonstrating need (e.g., an outstretched hand during snack time), but did not engage in these behaviors during control conditions when the experimenter did not demonstrate need. Children of this age did not spontaneously engage in comforting behaviors even with more explicit cues, such as when the experimenter alternated their gaze between their hurt knee and the child after verbalizing their pain. However, this is in contrast to other studies that have demonstrated early emergence of comforting behavior in toddlers (Zahn-Waxler et al., 1992).

Not all children are able to accurately interpret social cues or have the motivation to attend to such cues, which can negatively impact the ability to engage in culturally–appropriate prosocial behaviors. In particular, children with Autism Spectrum Disorder (ASD) display impairments in social motivation (Chevallier, Kohls, Troiani, Brodkin, & Schultz, 2012; Dawson, 2008; Dawson et al., 2002, 2005; Grelotti, Gauthier, & Schultz, 2002; Schultz, 2005) and interpreting social cues (Baron-Cohen, Campbell, Karmiloff-Smith, Grant, & Walker, 1995; Jellema et al., 2009; Senju, Southgate, White, & Frith, 2009) that impacts their desire and competency to attend to others. These impairments include difficulty interpreting facial expressions (see Harms, Martin, & Wallace, 2010 and Uljarevic & Hamilton, 2013 for reviews) and using eye gaze to interpret mental states and social intentions (e.g., Leekam, Hunnisett, & Moore, 1998; Mundy, Sigman, Ungerer, & Sherman, 1986; Pelphrey, Morris, & McCarthy, 2005). Proficiency in these areas can be vital in knowing when and how to engage in prosocial behaviors.

Due to the difficulties characteristic of ASD, it would be expected that children with ASD display impairments in the successful interpretation of social cues and subsequent execution of prosocial behaviors. However, only a handful of studies have examined this. Studies have found reduced prosocial scores in children with ASD in comparison to typically developing children as reported by caregivers using the prosocial subscale of the Strengths and Difficulties Questionnaire (Jones & Frederickson, 2010; Russell et al., 2012). Other studies have examined these behaviors experimentally. Travis, Sigman, and Ruskin (2001) examined prosocial behaviors — defined in this instance by sharing and helping — of both children with ASD and children with Down syndrome. To measure sharing, children were given the opportunity to share their food with the experimenter and to share photographs with an experimenter who expressed interest in viewing them. To measure helping, children were given the opportunity to help the experimenter clean spilled juice from the table and set down a full tray on a table covered in objects. In all trials, children were given explicit hints and verbal prompts if they did not immediately engage in the targeted behaviors. Based on these trials (two trials each for sharing and helping), children with ASD engaged in reduced helping and sharing behaviors in comparison to children with Down syndrome. Liebal, Colombi, Rogers, Warneken, and Tomasello (2007) contrived situations during which children with ASD and children with developmental delay (DD) were given multiple opportunities to hand an experimenter objects that were out of reach. While results demonstrated that children with ASD helped less, this difference was only marginally significant ($p = .06$). However, neither Travis et al. (2001) nor Liebal et al. (2007) used a typically developing control group so it is difficult to determine how behaviors observed in children with ASD differ from what may be observed in typically developing children.

Paulus and Rosal-Grifoll (2017) examined helping and sharing in three– to six–year–old children with ASD in comparison to typically developing children. To measure sharing, children engaged in a resource allocation task during which they had the opportunity to share ten stickers with two fictional children. To measure helping, as the experimenter left the room, he/she accidentally knocked over a cup full of pencils onto the floor. No verbal or social cues were given to indicate that the pencils should be picked up while they were away. During the sharing task, children with ASD engaged in increased sharing, giving away more stickers to the two children than the amount typically developing children gave away. During the helping task, children with ASD engaged in increased helping behavior in comparison to the typically developing children, although as the authors mentioned, this difference may be related to a desire to restore order to physical objects. Although not the only explanation, this study seemed to demonstrate increased prosocial behaviors in comparison to typically developing children.

Given the lack of experimental research in this area, and mixed findings in the studies that do exist, more work is required to draw conclusions about how social communication impairments in children with ASD affect prosocial behaviors and what mechanisms may underlie those impairments. One method of gaining information about ASD is examining typically developing individuals who demonstrate characteristics of ASD. In recent years, there has been a shift towards viewing ASD not as a spectrum separate from the general population but rather as the extreme end of continuous distribution of social and communication ability in the general population (Baron-Cohen et al., 1995; Constantino & Todd, 2003; Frith, 1991; Posserud, Lundervold, & Gillberg, 2006; Wing, 1988). As such, autistic traits — at sub-clinical levels — are thought to be distributed within the general population (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001) — including children (Posserud et al., 2006) — and can impact typically developing individuals' social functioning. In contrast to most previous research categorizing children as either ASD or typically developing, a more nuanced measure of autistic traits in children with and without ASD may reveal the specific characteristics that lead to social communication impairments in children with ASD.

One study that we know of has taken this approach to gain information about individuals with ASD through examining autistic traits in the general population and prosocial behaviors. Jameel, Vyas, Bellesi, Roberts, and Channon (2014) used a series of everyday scenarios to examine prosocial behaviors in neurotypical adults with high and low levels of autistic traits. Participants were shown scenarios in which a main character was in need of help and the participant was the only person available to assist. The participant was asked what they would do in the situation (free response). Then, they were given a choice of three actions they could (theoretically) engage in, ranging from low in prosocial behavior to high in prosocial behavior. Results indicated that those with high levels of autistic traits generated behaviors and responses that were less prosocial than those with low levels. However, this task was not able to assess for real-time social cues as the scenarios involved printed stories rather than live actors.

As little research has been done examining how social communication impairments impact prosocial behaviors in children, this study examined whether impairment in recognizing and using social cues (i.e., as measured by autistic traits) contributes to deficits in prosocial behaviors. If those with high levels of autistic traits demonstrate similar social difficulties as those seen in children diagnosed with ASD, then examining these individuals can also help inform our knowledge of ASD. Therefore, the aim of this study was to examine if the level of autistic traits in typically developing children predicts their ability to use social cues to engage in three different prosocial behaviors: helping, sharing, and comforting.

3.2 Method

Participants. Participants consisted of 27 four-and-a-half to six-year-old typically developing children (16 male, M = 5.18 years, SD = 0.5) recruited from a preexisting database of parents in San Diego County who expressed interest in participating in studies at the University of California, San Diego (UCSD) Department of Psychology. Of participants, 56.6% of parents reported their child as being of Caucasian ethnicity, 16.8% as Asian American/Pacific Islander and Caucasian, 11.1% as mixed ethnicity, 5.6% as Asian American/Pacific Islander, 5.6% as Caucasian and Native American, and 5.6% as Asian American/Pacific Islander and mixed ethnicity. Seventy-four percent of parents reported a combined household income of greater than \$100,000 with the remaining 26% of parents reporting an income of between \$60,000 and \$100,000. All parents gave written, informed consent. This study was approved by the Institutional Review Board at UCSD.

Questionnaire Measures. Caregivers were asked to complete two questionnaires to assess their child's social skills and autistic traits.

Autism-Spectrum Quotient-Child (AQ): The AQ (Auyeung, Baron-Cohen, Wheelwright, & Allison, 2008) is a 50 item measure used to assess level of autistic traits in the general population, and includes 5 subscales: social skills, attention switching, attention to detail, communication, and imagination. Items are rated by caregivers on a 4–point scale, from 0 – "definitely agree" to 3 – "definitely disagree," and are reverse scored as needed. Higher scores indicate greater presence of autistic traits, with a maximum score of 150 points. The AQ has good test-retest reliability (r = 0.85) and high internal consistency ($\alpha = 0.97$).

Strengths and Difficulties Questionnaire (SDQ): The SDQ (Goodman, 1997) is a caregiver report measure of an individual's strengths and difficulties in social domains such as peer relationships, prosocial behaviors, and emotional symptoms. As the purpose of this study was to examine prosocial behaviors, only those questions related to prosocial behaviors were used in the analyses. Higher scores on the prosocial subscale are indicative of increased levels of prosocial behaviors. The SDQ has good internal consistency (mean $\alpha = 0.73$) and test-retest reliability (mean r = 0.63).

Prosocial Tasks. Participants were presented with five test trials (two helping, two sharing, and one comforting). During the prosocial tasks listed below, the level of cue provided to indicate a need for assistance was manipulated. The set of cues were the same as was used in Warneken and Tomasello (2006), and were as follows: 1–10 seconds – the experimenter gazed at the object; 11–20 seconds – the experimenter alternated their gaze between the object and the child; 21–30 seconds – the experimenter alternated their gaze between the object and child and verbalized their need. Each task ended upon successful completion of the behavior, a verbal indication by the child that they did not want to engage in the expected behavior (e.g., "I don't want to give you any of my monkeys"), or after 30 seconds had commenced. Upon successful completion of the behavior, no praise was given. For feasibility sake, the paper ball helping task was always completed first, with the order of the remaining tasks randomized for each child.

Helping: These tasks resemble the methods used in Warneken and Tomasello (2006), during which children were given the opportunity to assist the experimenter in obtaining objects out of reach. In the first task, the experimenting table was set up such that there were seven pieces of balled up paper; two of which were situated close to the experimenter, while the remainder were situated close to the child (outside of the experimenter's reach). During the second helping task, the experimenter accidentally knocked over a cup full of pens. In both tasks, the experimenter picked up the two objects within reach and stretched their hand out for the remaining objects. The experimenter then proceeded through the aforementioned cues, specifically gazing at the paper/pens accordingly.

Sharing: At the start of the session, children were given three small toy monkeys as a thank you for participating, and were told they could take them home at the end of their time in lab. At a later point in the session, the experimenter asked to see the monkeys and indicated a desire to have one (e.g., "I really wanted to take a monkey home with me but you got the last ones!"). In the second task, the child and experimenter each had a box full of blocks, and the child was encouraged to play with his/her blocks while the experimenter played with her respective blocks. The boxes were contrived such that the experimenter received fewer blocks than the child, although the child was unaware of this fact. After building a tower with all the blocks given, the experimenter said, "Oh no! I am out of blocks!" while displaying distress. The experimenter then proceeded through the aforementioned cues, specifically gazing at the monkeys/blocks accordingly.

Comforting: This task was modeled off a similar task administered by Dunfield et al. (2011). The experimenter "accidentally" bumped her elbow on the table and vocalized her pain (e.g., "Ow! I hurt my elbow!") while displaying a look of distress. The experimenter proceeded through the previously mentioned cues, specifically gazing at her "hurt" body part.

Coding. Each session was videotaped and later coded by two research assistants blind to the purpose of the study. Coders overlapped on 20% of the participants, with 98% reliability. Discrepancies were resolved by consensus. For all trials, behaviors were coded on the successful completion of the targeted behavior (1 per trial) and the level of cue (1-3) given prior to the targeted behavior of the child. As the research aim was to examine the recognition and interpretation of social cues, if the child gave a verbal indication that they did not want to engage in the expected behavior (e.g., "I don't want to give you any of my monkeys"), then the level of cue prior to the statement was counted. Successful completion of the targeted behavior involved the participant sharing or helping the examiner, regardless of how many objects were shared or helped. For the comforting behaviors, verbal responses by the child were coded to determine if prosocial behaviors occurred. Responses were coded as one of two different types: 1) a non-comforting response (e.g., "You hit your elbow") or 2) a comforting/empathetic response (e.g., "That's too bad!") with comforting/empathetic responses classified as a prosocial behavior. To examine completion of prosocial behaviors throughout the session, the number of successfully completed prosocial behaviors was summed, leading to a maximum of five. To examine the separate components of prosocial behaviors, successful completion of prosocial behaviors for each component was summed, leading to a maximum of two each for helping and sharing, and one for comforting. To examine the level of cues needed throughout the session, the level of cue used was summed across trials, leading to a maximum of fifteen.

Analyses. All analyses used an analysis of variance (ANOVA), with AQ score as predictor variable, and the prosocial subscale of the SDQ, the total prosocial behaviors performed in-lab, and the total number of cues used as the outcome variables. To examine if autistic traits influenced the separate components of prosocial behaviors differently, an ANOVA was performed with AQ as predictor variable and each of the sharing, helping, and comforting behaviors as outcome variables.

3.3 Results

For helping behaviors, 15% of participants engaged in only one helping behavior, while 81% engaging in both helping behaviors. For sharing behaviors, 56% of participants engaged in only one sharing behavior, while 22% engaging in both sharing behaviors. For comforting, 41% of participants engaged in the comforting behavior (Figure 3.1). On average, children engaged in 3.11 prosocial behaviors ($SD = 1.05$, range = 1–5) and used 8.41 cues ($SD = 2.15$, range = 5–12). No relationship was observed between AQ score and helping, sharing, or comforting (all ps > 0.1). Scores on the AQ ranged from 17 to 70, with a mean of 45.4 and a standard deviation of 13.0.

There was a significant negative correlation between the total AQ score and the SDQ prosocial subscale ($F(1,26) = 8.89$, $R^2 = 0.26$, $p < 0.01$), such that as AQ scores increased, prosocial scores decreased (Figure 3.2). No relationships between the AQ and total prosocial behaviors, the SDQ prosocial subscale, or total cues used (ps > 0.1) were present. Additionally, no relationship between the total prosocial behaviors and the SDQ prosocial subscale ($p > 0.1$) was present.

3.4 Discussion

The purpose of this study was to examine if individual variation in autistic traits impact children's ability to use social cues to engage in prosocial behaviors. To test this, parents completed questionnaires that assessed perception of their child's prosocial behaviors and presence of autistic traits. In lab, situations were contrived that gave children the opportunity to engage in prosocial behaviors with an experimenter, while systematically increasing the cue provided. Consistent with expectations, children with higher levels of autistic traits were reported by parents as having decreased prosocial skills in comparison to those with lower levels of autistic traits. This provides evidence that typically developing children who demonstrate subtle signs associated with ASD are negatively impacted in their social behaviors. While this is the first study that we know of that has used the SDQ to examine prosocial difficulties while also measuring the presence of autistic traits in typically developing children, this was in line with past research demonstrating decreased prosocial scores on the SDQ in children who have a diagnosis of ASD (Jones & Frederickson, 2010; Russell et al., 2012). However, these findings are in contrast to Paulus and Rosal-Grifoll's (2017) experimental study that demonstrated intact prosocial behaviors in children with ASD. Due to these inconsistencies, more experimental research involving in-lab measures of prosocial behaviors, while comparing typically developing children and children with ASD, as well as children with various levels of autistic traits, are necessary.

Surprisingly, there was no relationship between scores on the SDQ or the AQ on prosocial behaviors observed during the experimental portion of this study, or between scores on the AQ and the total number of cues used. There are a few potential explanations for the lack of findings. First, our sample size and the variability in levels of autistic traits may not have been high enough for differences in prosocial behaviors to emerge. As such, future studies may want to recruit a large sample of typically developing children, and then only examine those children who have extremely high and extremely low levels of autistic traits (as Jameel et al. (2014) did in adults). Secondly, the parent report measure may have over-reported prosocial behaviors in comparison to in-lab behaviors. The SDQ prosocial subscale asks parents to indicate how true statements are about their child, such as "Helpful if someone is hurt, upset, or feeling ill" (Goodman, 1997). The instructions for parents do not specify whether these behaviors need to occur spontaneously or with the help of parental prompt. However, in-lab, children were not explicitly told to engage in these behaviors nor were they rewarded once prosocial behaviors occurred. This may have led to decreased prosocial behaviors compared to what parents typically observe. Additionally, when completing the SDQ, parents may reflect back on instances of prosocial behaviors which they personally observed. Research demonstrates a strong presentation bias such that children engage in increased prosocial behaviors when observed by others (Engelmann, Over, Herrmann, & Tomasello, 2013; Shaw et al., 2014; Yazdi, Barner, & Heyman, 2016). This presentation bias may be exacerbated by parental presence, which was not a factor during the in-lab portion. Differences between parent-report of children's prosocial ability and in-lab observations underscore the importance of experimentally measuring prosocial behaviors in conjunction with parental report. Lastly, while this study was designed to examine prosocial behaviors in a naturalistic manner, these opportunities may have felt overly contrived to children. As such, they may have felt expected to engage in prosocial behaviors.

During the study, children were given the opportunity to engage in prosocial behaviors to the benefit of an unfamiliar adult, in an unfamiliar setting. The behaviors observed in this study may differ from what is seen when children interact with familiar adults or peers of their own age, or in a familiar setting, as children may show increased prosocial behaviors when interacting with familiar individuals. Future studies should manipulate the familiarity, and age, of the partner to gain a more comprehensive understanding of the impact that autistic traits have on prosocial behaviors.

Prosocial behaviors can vary based on different societal norms and emphasis placed on the importance of prosocial behaviors(e.g., House, 2016; House et al., 2013; Ma, 1989; Mesurado et al., 2014). For example, in many Western societies, a strong emphasis is placed on outward displays of emotion and eye contact (Carpenter, Nagell, Tomasello, Butterworth, & Moore, 1998; Moore, 2008) that is not seen in other cultures (Gaskins, 2000; Kärtner, Keller, & Yovsi, 2010; Richman, Miller, & LeVine, 1992). Individuals from different cultures can vary in their response to displays of emotion, which in turn can impact the execution of prosocial behaviors. Rajhans, Altvater-Mackensen, Vaish, and Grossmann (2016) examined the relationship between children's prosocial behaviors and emotion responsiveness in India and Germany. In both cultures, increased responsiveness to emotional faces (specifically fearful faces) was associated with increased prosocial behaviors. Cultural differences were also apparent, with greater prosocial behaviors associated with increased sensitivity to context when responding to fearful faces in Indian children. Becoming competent in this aspect of one's culture requires a process of learning the appropriate responses to social cues as dictated by culture. As such, children from one culture may come to rely on different social cues to indicate distress and need than those from another culture. Lastly, the emphasis the parents place on engaging in prosocial behaviors can vary. Future studies would benefit from using questionnaires to assess cultural norms and parental emphasis related to prosocial behaviors.

Based on parent report, this study demonstrated a negative correlation between prosocial behaviors and level of autistic traits. Through using a measure of autistic traits, we were able to examine how variability in social communication ability impacts typically developing children's social behaviors. Additionally, through examining autistic traits in typically developing children, information can be gleamed about children with ASD more broadly, as their symptoms are at the extreme end of a continuum of autistic traits in the general population (Baron-Cohen et al., 1995; Constantino & Todd, 2003; Frith, 1991; Posserud et al., 2006; Wing, 1988). Results from the parent questionnaire measure of prosocial behavior replicated what has been observed in children with ASD based on parent report (Jones & Frederickson, 2010; Russell et al., 2012) and in experimental measures when compared to developmentally delayed and Down syndrome groups (Liebal et al., 2007; Travis et al., 2001; although not in comparison to typically developing children, Paulus & Rosal-Grifoll, 2017). If characteristics of ASD do negatively impact prosocial behaviors there are a variety of reasons why this may be.

Difficulty understanding social cues is not the only impairment that can lead to decreased prosocial behaviors in individuals who display autistic traits or who have a diagnosis of ASD. The successful completion of prosocial behaviors involves at least three steps: 1) recognizing an individual is in need, 2) understanding how to assist and having the necessary means to assist the individual in need, and 3) being motivated to assist the individual (Dunfield & Kuhlmeier, 2013). Children with decreased social skills, as characteristic of individuals who have a diagnosis of ASD, may show impairments at any of these stages which negatively impact their ability to perform prosocial behaviors. For example, decreased levels of social motivation, such as those postulated as being present in individuals with ASD (Chevallier et al., 2012; Dawson, 2008; Dawson et al., 2002, 2005; Grelotti et al., 2002; Schultz, 2005; Senju et al., 2009), may impact the choice to assist another individual (hindering step two). Difficulty understanding the intention of others, due to difficulties in areas such as interpreting facial expressions, following eye gaze, and Theory of Mind (as seen in ASD, e.g., Harms et al., 2010; Leekam et al., 1998; Mundy et al., 1986; Pelphrey et al., 2005; Uljarevic & Hamilton, 2013), can impact knowing the best course of action when assisting others (hindering step three). Future studies should investigate which of these stages, if any, are negatively impacted by autistic traits to better understand how impairments in ASD impact social behaviors.

One possible limitation arose as a result of the design of the sharing tasks. While most children engaged in sharing behavior during the block task (67%), very few children shared their toy monkeys with the experimenter (33%). When given the toy monkeys as a thank you for participating, the experimenter emphasized that the toy monkeys were now under the ownership of the child, and could be brought home. In contrast, during the block task, there was no transfer of ownership and presumably the children knew that upon completion of the task, the blocks would stay in the laboratory. Therefore, the personal cost associated with sharing the monkeys was much higher than the cost associated with sharing the blocks. Additionally, the toy monkeys may have been more novel for the children and as such, more rewarding. This may have prevented children from wanting to share with the experimenter.

The aim of this study was to examine prosocial behaviors through asking if children with high levels of autistic traits are impacted in their ability to recognize and interpret social cues. This study found, through parent report, that children with higher levels of autistic traits display lower levels of prosocial behaviors. However, due to the conflicting results between the parent-report measure of prosocial behaviors and the experimental measure of prosocial behaviors, more research is needed to better understand the impact of autistic traits on prosocial behaviors. Examining the impact of autistic traits on social competency is an important step to better understanding not just individuals with ASD, but also variation in social communication ability in the general population.

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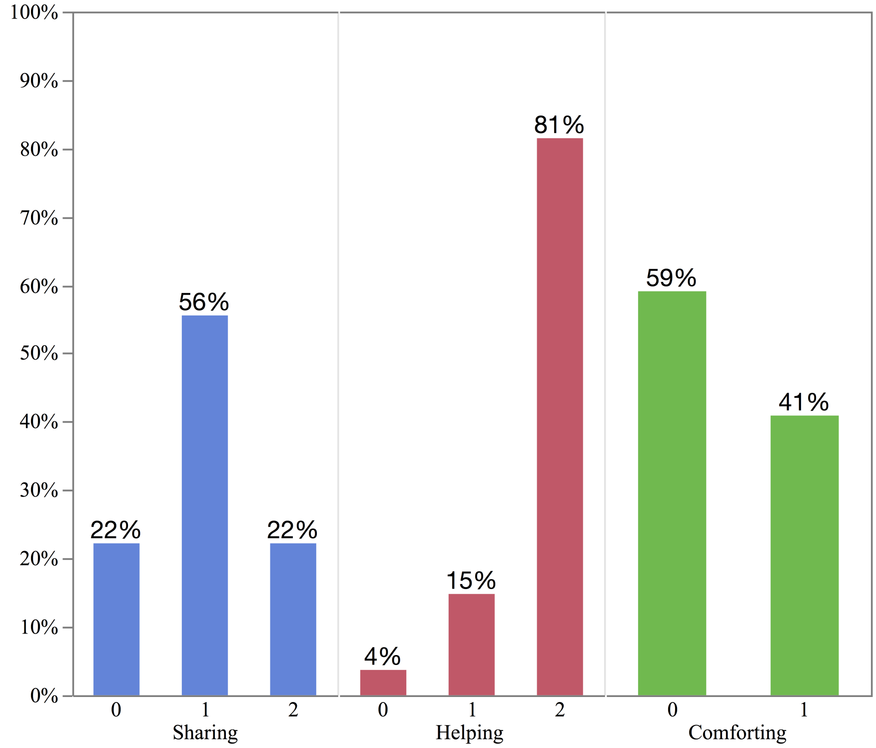

Figure 3.1: Percent of participants who engaged in a total of 0, 1, or 2 sharing, helping, and comforting prosocial behaviors

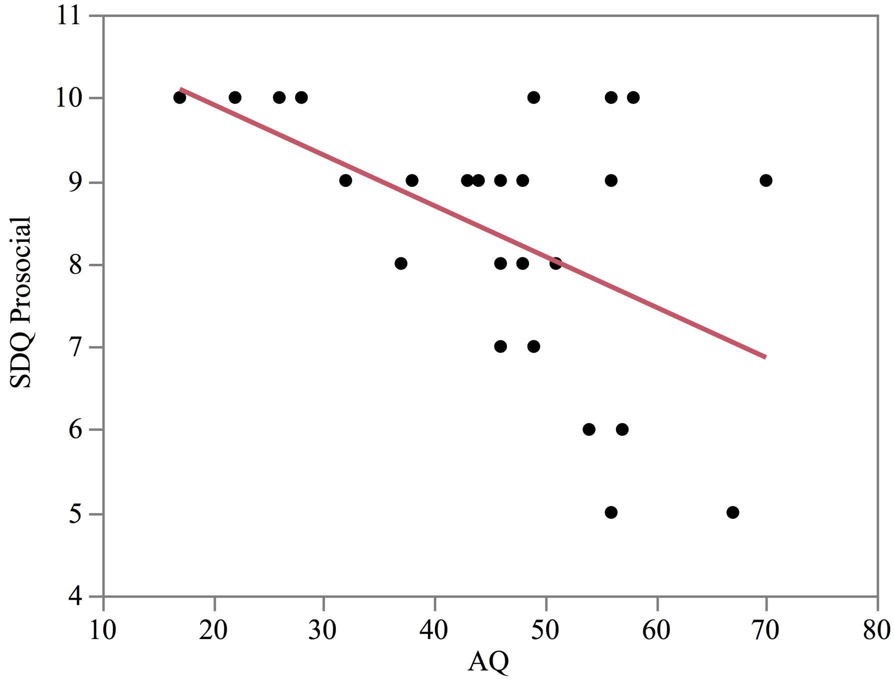

Figure 3.2: Correlation between AQ scores and the SDQ Prosocial subscale

General Discussion

The social world is a complex place and learning how to effectively navigate the myriad sensations, experiences, and interactions is necessary for optimal survival. However, not all individuals respond to these environmental cues in the same manner. Across three studies, this dissertation examined if children vary in response to lower level sensory cues and higher level social cues based on differences in temperament and characteristics of Autism Spectrum Disorder (ASD).

Chapter One examined how risk for, and diagnosis of, ASD influenced infants' and teenagers' experience with their sensory environment. To this end, caregivers of infants at high and low risk for ASD, and adolescents with and without a diagnosis of ASD, completed the Sensory Profile questionnaire (infants, Infant/Toddler Sensory Profile (ITSP), Dunn, 2002; teenagers, Adolescent/Adult Sensory Profile (AASP), Brown & Dunn, 2002). Responses indicated that high-risk infants and teenagers with ASD endorsed a higher frequency of unusual sensory behaviors (USBs) than their low-risk and neurotypical counterparts. Additionally, not only did high-risk infants and teenagers with ASD indicate a higher frequency of USBs overall, even when low-risk infants and adolescents without ASD endorsed USBs, USBs in high-risk infants and teenagers with ASD manifested in different patterns (i.e., whether behaviors occurred at atypically high or atypically low frequencies). This indicates that characteristics of ASD play a role in how infants and teenagers experience low level sensory cues.

To examine children's variation in response to social cues in the environment, Chapter Two manipulated social characteristics (i.e., positive or neutral emotional expression) of a partner during a social learning paradigm. Parents of 18- to 24-month-old toddlers completed a measure of temperament (Early Childhood Behavior Quesionnaire-Very Short (ECBQ), Putnam, Jacobs, Garstein, & Rothbart, 2010) to address the role temperament (i.e., surgency) plays in children's response to social cues of a partner and when learning from others. When the social partner displayed signs of neutral affect (e.g., decreased smiles, flat intonation), toddlers — irrespective of temperament style — frequently referenced their parent, potentially to determine the appropriate manner to behave in this novel setting. Toddlers' temperament style did not significantly influence children's social or learning behaviors. These findings underscore the importance of examining the impact of cues such as emotional expression on children's social behaviors to better understand how the social environment influences children. Additionally, as we did not find differences in learning during the imitation paradigm dependent of the social characteristics of the partner, this may provide evidence for the ability of toddlers to effectively learn from individuals, regardless of the social input they are receiving during these interactions.

The aim of Chapter Three was to investigate the role that autistic traits play in children's use of cues to guide social behaviors. Through systematically increasing the overtness of social cues, this study examined if children with higher levels of autistic traits required more overt social cues to engage in prosocial behaviors. Although we anticipated that children with higher levels of autistic traits would need more cues, no differences were observed. Based upon parent report, children with higher levels of autistic traits demonstrated decreased levels of prosocial behaviors, but this difference was not observed in the in-lab measure. These results provide evidence that autistic traits have an impact on completion of prosocial behaviors, but potentially not as a result of difficulty interpreting social cues. Further research using prosocial paradigms should be done to determine which underlying difficulties characteristic of ASD are negatively impacting prosocial behaviors, as well as to examine discrepancies between parent perception of prosocial behaviors and in-lab measures.

An important consideration for this work — and the literature on development and ASD more broadly — is that this set of studies sampled children from a WEIRD (Western, educated, industrialized, rich, and democratic; Henrich, Heine, & Norenzayan, 2010) society. As such, results from these studies may not generalize to children in other societies due to variation in environment and societal norms. For example, in Chapter One, parents reported their child's reaction to various sensations in their environment. However, behavioral reactions such as crying or covering the ears when exposed to an aversive sensation (as frequently seen in Western societies) can differ dependent on the societal acceptability of those reactions. Because of this, sensory difficulties may be hard to measure with a questionnaire such as the Sensory Profile as reactions may differ not based on the sensation experienced, but on societal norms.

Expectations regarding social behaviors and displays of emotion vary by society as well. In Chapter Two, we examined if social behaviors varied in response to an experimenter's display of affect. While engaging with a person displaying neutral affect may be a novel, and potentially uncomfortable, situation for children in Western societies, this is not necessarily true in societies where positive displays of affect are not emphasized (Akhtar & Gernsbacher, 2008; Keller, 2002). Rather than displays of neutral affect being novel and uncomfortable, in other societies positive affect may make toddlers uncomfortable, leading them to seek out comfort and reassurance from their parent. In Chapter Three, we manipulated the social cues available to children that indicated prosocial behaviors were warranted. These cues included changes in emotional expression and gestures that were reflective of cues commonly used in western societies to indicate need. However, these cues may not be universal signals across societies and future studies examining more diverse populations should ensure that cues used are appropriate for the population being sampled.

In both Chapter Two and Chapter Three, the particular social paradigms examined (i.e., imitation and prosociality) are also influenced by culture. Children's propensity to imitate the actions of others varies by context (conventional versus instrumental tasks) and culture (Clegg & Legare, 2016). Prosociality can also vary by society dependent on societal norms (e.g., House, 2016; Ma, 1989; Mesurado et al., 2014), as well as the availability of resources present in that society (House et al., 2013). Future studies should utilize more diverse samples and examine this question in other cultures to gain a better understanding of the impact of individual variation on the interpretation and use of environmental cues before making conclusions about development more broadly.

With regard to future directions, one avenue that would be useful to explore would be to use the Sensory Profile questionnaire (Brown & Dunn, 2002; Dunn, 2002), the ECBQ (Putnam et al., 2010) and the Autism-Spectrum Quotient (Auyeung, Baron-Cohen, Wheelwright, & Allison, 2008) across all three chapters to better understand how nuanced variation in sensory sensitivity and social communication impact a variety of behaviors seen in children's day-to-day lives. Using the Sensory Profile in Chapters Two and Three would be a future avenue to explore to determine if difficulties in sensory processing are indicative of, or related to, variation in use of social cues as past research has demonstrated increased social difficulties in individuals with sensory atypicalities (Ben-Sasson, Carter, & Briggs-Gowan, 2009; Kinnealey & Fuiek, 1999; Stagnitti, Raison, & Ryan, 1999). For example, if an individual is fixated on sensory stimuli they may miss attending to other important social cues. Additionally, adding the Autism Spectrum Quotient (Auyeung et al., 2008) to Chapters One and Two would provide additional information about the influence that autistic traits have on typically developing children's reaction to sensory and social cues in the environment.

While Chapter Two examined the impact of surgency on imitation and social engagement in toddlers, to gain a better understanding of individual variability other aspects of temperament such as activity level or mood control may prove beneficial to study. In order to investigate potential impacts of autistic traits on prosocial behaviors, future studies could use other tests of social cognition examining Theory of Mind, executive functioning, and empathy to determine if those characteristics play a role in prosocial behaviors as well. Studies may also benefit from having children read different prosocial scenarios, state what action they would take, and then explain the reasoning behind their hypothetical action. In this manner, prosocial behaviors could be examined in those with various levels of autistic traits without any influence of social cues. Alternatively, researchers could examine children in a setting more reflective of their typical environment, such as during play time at school, to assess prosocial behaviors in a naturalistic setting. It would also be important to gain information about societal norms and parental influences on both imitative and prosocial behaviors that may explain variability in children.

Chapter One revealed differences in reaction to low level sensory cues dependent on risk and diagnosis of ASD, Chapter Two demonstrated the impact that social cues have on toddlers, and Chapter Three demonstrated the impact that social cues have on children when engaging in social behaviors, varying by level of autistic traits. Taken together, these findings demonstrate that the sensory and social cues to which children attend and their subsequent behavioral reactions to these cues differ across clinical populations (i.e., characteristics of Autism Spectrum Disorder), but no evidence was found that they differ based on individual variation in temperament. These findings have implications for an improved understanding of the nuances of sensory processing and social behavior that can ultimately inform improved interventions for helping children with social communication deficits navigate the complex social world.

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