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TACTILE RESPONSIVENESS PATTERNS AND THEIR ASSOCIATION WITH CORE FEATURES IN AUTISM SPECTRUM DISORDERS

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Abstract

Autism spectrum disorders (ASD) are often associated with aberrant responses to sensory stimuli, which are thought to contribute to the social, communication, and repetitive behavior deficits that define ASD. However, there are few studies that separate aberrant sensory responses by individual sensory modality to assess modality-specific associations between sensory features and core symptoms. Differences in response to tactile stimuli are prevalent in ASD, and tactile contact early in infancy is a foundation for the development of social and communication skills affected by ASD. We assessed the association between three aberrant patterns of tactile responsiveness (hyper-responsiveness, hypo-responsiveness, sensory seeking) and core symptoms of ASD. Both sensory and core features were measured with converging methods including both parent-report and direct observation. Our results demonstrate that for the tactile modality, sensory hypo-responsiveness correlates strongly with increased social and communication impairments, and to a lesser degree, repetitive behaviors. Sensory seeking was found to correlate strongly with social impairment, nonverbal communication impairment, and repetitive behaviors. Surprisingly, tactile hyper-responsiveness did not significantly correlate with any core features of ASD. This differential association between specific tactile processing patterns and core features provides an important step in defining the significance of sensory symptoms in ASD, and may be useful in the development of sensory–based approaches for early detection and intervention.

Keywords

autism spectrum disorders; sensory; tactile; symptoms; somatosensory

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1. Introduction

Autism spectrum disorders (ASD) are defined clinically by impairments in social interaction and communication, and repetitive patterns of behavior, with onset at or before 3 years of age (APA, 2000). The psychiatrist Leo Kanner first described autism in the 1940's, and included in his view of the disorder were apparent differences in sensitivity to external sensory stimuli (Kanner, 1943). Since then, sensory symptoms have been speculated to contribute to aberrant social, communication, and repetitive behaviors (Ornitz, 1974; Lovaas, Newsom, & Hickman, 1987), but have not been included among the core diagnostic symptoms because of a need for stronger empirical evidence for their extent and specificity in autism spectrum disorders (Rogers & Ozonoff, 2005). As evidence regarding the import of sensory-related symptoms continues to accumulate (Ben-Sasson et al., 2009), the proposed DSM-V (anticipated release date: May 2013) criteria are expected to explicitly include unusual sensory behaviors as a diagnostic feature for ASD under the category of repetitive behaviors (APA, www.dsm5.org).

1.1 Sensory Patterns in Autism Spectrum Disorders

Baranek and colleagues observed three sensory response patterns in children with ASD, though these patterns are not mutually exclusive and often co-occur within an individual (Baranek, David, Poe, Stone, & Watson, 2006). First, individuals may exhibit *hyper-responsiveness*[1] toward common environmental stimuli such as vacuum cleaners or wool clothing, suggesting a lowered threshold for registering and/or ascribing negative affective significance to sensory events that most people find innocuous. Along these lines, there is often a lack of habituation to repeated or continuous sensory stimulation (such as the sound of an air conditioner running). Individuals exhibiting these traits may go to great lengths to avoid stimuli they find aversive. Individuals with ASD may also exhibit *hypo-responsiveness* to environmental stimuli. In this pattern, there is a failure to register or respond to sensory inputs, such as a tap on the shoulder or the sound of one's name being called. This trait may manifest as reduced responsiveness to one's environment or high pain tolerance. A third pattern is *sensory seeking,* which describes behaviors that reflect a craving for or unusually strong attraction toward certain types of sensory input (e.g., peering at lights or spending disproportionate amounts of time on a swing). Hypo-responsiveness and (purportedly compensatory) seeking behaviors might be expected to co-occur, but empirical support for this link has not been reported consistently. Rather, hypo-responsiveness can occur alone or along with sensory seeking behaviors (Lane, Dennis, & Geraghty, 2010).

Undoubtedly, some ambiguity about the role of sensory features as they relate to core features can be attributed to the heterogeneity of their presentation in ASD and their lack of specificity to ASD. Two or more sensory processing patterns may co-occur in the same individual, and the nature and extent of sensory difficulties may fluctuate within individuals across environments (Brown & Dunn, 2010) to a greater degree than social and communication deficits (Ben-Sasson et al., 2008). Baranek and colleagues (2007) found that across clinical groups, younger children are more likely to exhibit sensory hyper-responsiveness than older children. (Baranek, Boyd, Poe, David & Watson, 2007). Children with generalized developmental delay show more hyper-responsiveness than typically developing children, while hypo-responsiveness may be more specific to ASD. Different sensory modalities may be differentially affected in individuals with ASD, further contributing to the lack of clarity surrounding how sensory abnormalities present and relate to core deficits in ASD.

[1]The nomenclature used in this paper follows that of Baranek et al. (2006), and reflects an emphasis on observable/measurable behavior ('responsiveness') rather than presumed internal experience ('sensitivity').

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1.2 Relating Sensory Features to Core ASD Symptoms

Despite the complicated picture of sensory features in ASD, they may provide important clues to the etiology of core social, communication, and repetitive behavior symptoms in ASD. For example, some autobiographical accounts describe a feeling of being overwhelmed by sensory input as an impetus for social withdrawal (Gerland, 1997; Grandin, 1996), and empirical evidence suggests that sensory responsiveness predicts social severity in high functioning autism (Hilton, Graver, & LaVesser, 2007; Hilton et al., 2010), as well as across a broader range of the autism spectrum (Baker, Lang, Angley, & Young, 2008). There is also empirical evidence that sensory reactivity and adaptive behaviors are related (Rogers, Hepburn, & Wehner, 2003; Lane, Young, Baker, & Angley, 2010), although additional work is necessary to define the nature of this relation more precisely. Some repetitive behaviors are hypothesized to serve the function of regulating sensory input (Lovaas et al., 1987; Joosten, Bundy, & Einfeld, 2009), and studies have supported this by yielding significant relationships between sensory symptoms and repetitive behaviors (Baranek, Foster, & Berkson, 1997; Chen, Rogers, & McConachie, 2009; Boyd et al. 2010). Indeed, a retrospective video study demonstrated that sensory and motor features are predictive of later autism diagnosis (Baranek, 1999), while a prospective study verified that impaired sensory behaviors coexist with social-communicative symptoms in high-risk 6 month-olds who go on to develop autism (Bryson et al., 2007).

In spite of these converging lines of evidence for the importance of atypical sensory processing in the development of ASD, our understanding of how specific patterns of sensory responsiveness are related to the triad of impairments that characterizes ASD is far from complete. Knowledge of modality-specific impairments and their relations to core symptoms is sparse to date, as much of the literature collapses information across visual, auditory, vestibular, tactile, gustatory, and olfactory modalities when examining relations to autism symptoms. Thus, more work is needed to provide a clear picture of how patterns of atypical processing (i.e., hyper-responsiveness, hypo-responsiveness, sensory seeking) relate to the social, communication, and repetitive behavior symptoms in ASD. A modality-specific approach may be particularly critical in moving research on sensory processing in ASD forward, as previous studies collapsing across sensory systems may have obscured important relationships given the heterogeneity of sensory features in ASD across modalities (Kern et al., 2006). In this paper, we focus on tactile (somatosensory) symptoms.

1.3 The Somatosensory System and Development

Tactile symptoms are among the most commonly reported sensory features described by parents of children with ASD (Rogers et al., 2003; Tomcheck & Dunn, 2007). Paradoxically, the somatosensory system is studied much less widely than its visual and auditory counterparts. The relevance of hearing and vision for verbal communication likely is responsible for this bias, but it is important to consider the role of touch in pre-verbal socio-communicative development that lays the groundwork for more complex communication during a critical developmental window in infancy. Specifically, in the first two years of life, when the neurodevelopmental trajectory in ASD is presumed to begin diverging from that of typical development (Hazlett et al., 2005), preverbal communication and parent-child bonding relies heavily on somatosensory input (Myers, 1984; Montagu, 1986; Field, 2001). In addition, novelty exploration (Harlow & Harlow, 1962) and secure attachment (Main & Stadtman, 1981; Weiss, Wilson, Hertsenstein, & Campos, 2000) depend on early tactile stimulation. Conversely, lack of maternal tactile contact early in infancy is associated with repetitive behaviors that are characteristic of ASD (Harlow & Harlow, 1962). Dunbar (1996) suggests that tactile grooming behaviors in primates are the evolutionary precursor to verbal language, and that this phylogenetic role is recapitulated in the ontogeny of cuddling and skin-to-skin contact between preverbal infants and caregivers in human development. Thus, the early development of the tactile system may provide an important foundation for later-developing social and communicative behavior (Hertenstein, Verkamp, Kerestes, & Homes, 2006; Cascio, 2010).

1.4 Rationale for Current Study

Most reports of sensory symptoms in ASD rely on parent questionnaire, which has the benefit of high ecological validity (i.e., parents are reporting on everyday behaviors in the child's usual environment, in contrast to experimental measures that evaluate responses to novel stimuli in an unfamiliar laboratory environment), but has the potential for bias depending on how parents read and interpret each question in light of their child's individual behaviors and their impact on daily life. Direct observation of responsiveness to sensory stimuli is an important complement to existing research, providing an objective measure of sensory responsiveness that is unbiased by differences in parent reporting or children's environments or experiences. Baranek (1999) has developed observational measures for sensory processing that provide the opportunity for standardized laboratory assessment of real-time reactions to sensory stimuli. These measures have the benefit of providing a controlled environment, consistent sensory experiences from which to gauge children's responsiveness, explicit behavioral markers by which responses are rated, and the opportunity for improved inter-rater reliability. In this way, direct observational methods provide an important method by which to build upon and complement parent-reported sensory behaviors in children with ASD.

To advance our knowledge of how patterns of atypical sensory processing relate to ASD features, this study utilized a multi-method, modality-specific approach, combining direct assessment with parent report. Specifically, we used a direct observational measure of tactile symptoms (Baranek, 1999) and two parent questionnaires (Dunn, 1999, Baranek et al., 2006) to assess tactile processing, in combination with gold-standard observational and parent report data for ASD symptoms (Lord, Rutter, DiLavore, & Risi, 1999; LeCouteur, Lord, & Rutter, 2003). The goal of this study was to clarify the role specific patterns of tactile responsiveness, as they relate to core diagnostic features in young children with ASD.

2. Methods

2.1 Participant Sample

Thirty-four children with ASD (29 male, 5 female) between the ages of 5 and 8 years were included in the study. Participants were recruited from the university medical center and surrounding community, and diagnosis of ASD (i.e., autistic disorder, Asperger's Disorder, or Pervasive Developmental Disorder – Not Otherwise Specified) was confirmed with research-reliable administration of the Autism Diagnostic Observation Schedule (ADOS, Lord, et al., 1999) and Autism Diagnostic Interview-Revised (ADI-R, LeCouteur, et al., 2003), and the clinical judgment, based on DSM-IV criteria, of a licensed clinical psychologist with extensive experience with children with ASD. Of the 34 children in the sample, 19 were given the Module 3 ADOS, 7 were given Module 2, and 8 were given Module 1 based on expressive language levels. Summary scores were calculated according to the revised algorithms provided in Gotham, Risi, Pickles, and Lord (2007) and all children met ASD or autism cutoff scores for the module they were given. Based on lifetime history of ASD symptoms reported by parents on the ADI-R, all included children met ASD cutoffs, as specified by the ADI-R algorithms, in social, communication, and repetitive behavior domains.

All participants were screened and excluded for known comorbid genetic or neurological conditions, as well as uncorrected sensory problems that affected visual, auditory, or tactile

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perception. For most of the sample (n=24), cognitive ability was assessed with the Kaufman Brief Intelligence Test – Second Edition (KBIT-2, Kaufman & Kaufman, 2004); for 10 participants who were unable to obtain a basal on the KBIT-2 (e.g., because of markedly limited language abilities), the Mullen Scales of Early Learning (MSEL, Mullen, 1995) was used as a measure of cognitive level. Mental age (MA) was calculated by averaging verbal and non-verbal mental age equivalents, as provided in the KBIT-2 and MSEL manuals based on raw scores in each domain. Developmental quotient (DQ) was calculated by dividing a child's mental age by his/her chronological age and then multiplying by 100; thus, a child with a DQ of 100 has equivalent mental and chronological ages (i.e., is exactly on track, developmentally), whereas a child with a DQ of 50 has the cognitive ability of a child approximately half his/her chronological age. Participant characteristics are summarized in Table 1.

2.2 Procedures

All procedures were approved by the Vanderbilt Institutional Review Board. All parents gave informed consent prior to children's inclusion in the study. Children were monitored for signs of dissent throughout the study and children with adequate verbal abilities gave informed assent prior to beginning the study. All children were paid for their participation in study procedures.

Children were initially administered the ADOS and parents were interviewed with the ADI-R to determine whether they met diagnostic criteria for inclusion in this study, as well as to quantify social, communication, and repetitive behavior symptomatology. Thus, direct observation and parent report of social and communication impairments and of repetitive behaviors/restricted interests were obtained from standardized assessments for use in relating core symptoms to parent-report and direct observation of sensory functioning in the tactile domain.

Three measures of sensory processing were administered to children and their parents (Table 2). To obtain information regarding children's sensory functioning in the context of every-day life, parents completed the Sensory Profile (SP, Dunn, 1999) and the Sensory Experiences Questionnaire (SEQ, Baranek et al., 2006). Both measures focus on sensory symptoms such as hyper-responsiveness to everyday environmental stimuli and sensory seeking, and include several items focused on tactile processing specifically. The SP includes a section on tactile processing that divides items into "low threshold" (i.e., hyper-responsiveness) and "high threshold" (i.e., hypo-responsiveness) subsets. The SEQ classifies items related to hyper-responsiveness, hypo-responsiveness, and sensory seeking. Tactile items within each of these domains were the focus of this study.

Children were administered the Tactile Defensiveness and Discrimination Test-Revised (TDDT-R, Baranek, 1998). The TDDT-R is a 15–20 minute, structured observational assessment that includes self-directed tactile activities using materials such as sand, putty, textured surfaces, and vibrating toys, as well as brief, experimenter-administrated, innocuous touch stimuli applied to the child's hands, arms, and face.

Tactile defensiveness (hyper-responsiveness) is coded for each item; defensive behaviors include avoidance of the toy or activity, or negative affective reactions such as crying, grimacing, or rubbing the skin after interacting with the stimulus. For items such as sand and putty for which engagement is under the child's control, the degree of approach or avoidance is also coded, such that hyper-responsiveness codes include both aversiveness to the stimulus and degree of engagement with the stimulus. Seeking reactions are also coded for items during which engagement is under the child's control; seeking behaviors include excessive engagement with and/or very strong positive affective response to the stimuli. For

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both hyper-responsiveness (i.e., defensiveness) and seeking, an overall summary score is calculated by averaging the scores across individual items according to manualized procedures (Baranek, unpublished manual).

The TDDT-R was administered by trained personnel, videotaped, and scored by consensus, under the supervision of the senior author who was trained to reliability by the author of the instrument. Inter-observer reliability was estimated using absolute-agreement intra-class correlation coefficients (ICC), and was based on independent codings of videotapes from 21.2% of randomly selected TDDT-R administrations. The ICC was 0.951 for defensiveness behaviors and 0.904 for seeking behaviors.

2.3 Statistical analysis

Bivariate correlations were conducted between direct assessment (TDDT-R) and parent-report (SP and SEQ) measures of tactile hyper-responsiveness (defensiveness), hypo-responsiveness, and seeking behaviors and direct (ADOS) and parent-report (ADI-R) assessments of social, communicative, and behavioral differences in ASD.

3. Results

Complete datasets (including all three sensory measures, ADOS, and ADI-R, were obtained for 28 of the 34 children in the sample. Of the remaining six, one was missing the ADI-R, one was missing the TDDT-R, one was missing the SEQ and the SP, and three were missing the SEQ only. Verbal communication scores on the ADI-R were only calculated for those children with functional speech (N=27).

3.1 Tactile Seeking

Increased tactile seeking behaviors, as indexed on the TDDT-R and SEQ tactile section, was associated with increased social impairment on the ADOS (TDDT-R: r(31 = .376, p = .031; SEQ: r(28) = −.432, p = .017) and ADI-R (SEQ: r(27) = −.460, p = .012). Increased tactile seeking was also associated with increased repetitive behaviors on the ADOS (TDDT-R: r(31) = .360, p = .039; SEQ: r(28) = −.538, p = .002). Finally, tactile seeking behaviors were related to non-verbal communication impairments on the ADI-R (SEQ: r(25) = −.465, p = . 014) across all children, though not to verbal communication impairments reported in the ADI-R for the subset of children with functional speech.

3.2 Tactile Hypo-responsiveness

Higher levels of tactile hypo-responsiveness, as measured by the SP tactile high threshold items, were related to increased social impairment on the ADOS (r(31) = −.455, p = .008) and ADI-R (r(30) = −.508, p = .003), increased nonverbal communication impairments on the ADI-R (r(27) = −.524, p = .004), and increased repetitive behaviors on the ADOS (r(31) = −.439, p = .011), but not ADI-R. The SEQ index for tactile hypo-responsiveness was correlated with ADI-R report of increased social (r(27) = −.531, p = .003), non-verbal communication (r(25) = −.502, p = .008), and repetitive behavior (r(27) = −.379, p = .042) symptoms, though not with any ADOS domain scores.

3.3 Tactile Hyper-responsiveness (Defensiveness)

None of the measures of tactile hyper-responsiveness was correlated with any core ASD symptom domains, as measured by the ADOS and ADI-R.

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4. Discussion

The current study describes significant positive relations among social, communication, and repetitive behaviors and tactile seeking and hypo-responsiveness patterns in children with ASD, all assessed using converging methods of direct observation and parent report. Specifically, heightened levels of tactile seeking behavior were associated with greater levels of social impairment and repetitive behaviors, while increased hypo-responsiveness to tactile stimuli was related to greater levels of social impairment, non-verbal communication impairment, and repetitive behaviors. Tactile hyper-responsiveness, in contrast, did not relate to ASD symptoms. These results are consistent with prior work collapsing across sensory modalities and demonstrating that the hypo-responsiveness pattern best differentiates ASD from other developmental disabilities (Baranek et al., 2006), whereas hyper-responsiveness is less disorder-specific.

The most prominent relations defined by this study were between tactile hypo-responsiveness and seeking behaviors, as measured by the SP, SEQ, and TDDT-R, and social impairments and repetitive behaviors measured by the ADI-R and ADOS. Some have posited that hypo-responsiveness to external (sensory) input and faulty attentional mechanisms result in reduced social attention (e.g., joint attention, social orienting) in infancy (Dawson et al., 2004), leading to social impairment later on. Our findings of higher levels of tactile hypo-responsivity being related to greater levels of social impairment in children with ASD are consistent with this notion.

In terms of our observed relation between tactile seeking behaviors and increased social impairment, it has been proposed that dysfunction in neural reward systems might underlie reduced attentiveness and responsiveness to external stimuli, particularly with regard to social stimuli. For example, Mundy and Neal (2001) suggested that children with ASD might not find social stimuli and interaction inherently rewarding, and that non-social stimuli might hold heightened reward value for these children. Building upon this model, one could predict that sensory seeking behaviors reflect a child’s pursuit of alternative, non-social sources of reward, which could be particularly salient in children who derive the least reward from social stimuli. Indeed, some evidence for the reward value of sensory stimulation exists. Ingersoll, Schreibman, and Tran (2003) found that children with autism were more motivated to imitate with sensory rewards than with social rewards, and were generally more motivated by sensory feedback than were typically developing children. Further, Pernon and colleagues reported increased tactile seeking of air stimulation in children with ASD compared to children with other disabilities (Pernon, Pry, & Baghdadli, 2007) and noted that this tactile seeking behavior was associated with a strong positive affective response. These findings provide some evidence that sensory, and specifically tactile, input may be intrinsically rewarding for children with ASD, and suggest a mechanism by which increased sensory seeking behaviors may arise in ASD and relate to greater social impairment, particularly if social interactions lack typical reward value.

The relation between increased tactile hypo-responsiveness and seeking behaviors and more significant repetitive behavior symptoms observed in this study can be conceptualized in a similar manner. Specifically, early models suggested that hypo-responsiveness to environmental input, both social/affective and non-social, produced a state of sensory deprivation, which included failure to make typical reward attributions that would normally facilitate learning based on social cues (DesLauriers & Carlson, 1969). Repetitive patterns of behavior were thought to result from this state and subsequent research has supported this notion in finding that repetitive patterns of behavior and interests do, in fact, have abnormally *high* reward value in ASD (Lovaas et al., 1987; Mercier, Mottron, & Belleville; 2000; Dichter et al., 2010). Other research has suggested that repetitive behaviors may be

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related more directly to a child's (likely subconscious) attempt to compensate for states of under-arousal (Kinsborne, 1980), a prediction supported by the association between hypo-responsiveness and repetitive behaviors observed in the current study. Further, within this framework, repetitive motor mannerisms can themselves be conceptualized as sensory (i.e., vestibular, proprioceptive, tactile) seeking behaviors (Gal, Dyck, & Passmore, 2002, 2010). The relative role of repetitive behaviors and restricted interests for providing compensatory reward and/or sensory input remains to be clarified, as does the specific role of tactile seeking in this conceptualization.

Our results with regard to repetitive behaviors are partially inconsistent with those of Boyd et al. (2010), who found that sensory hyper-responsiveness, but not seeking or hypo-responsiveness, correlated with repetitive behaviors. Several possibilities for these discrepant results exist, including: 1) Boyd et al. used a more extensive measure of repetitive behaviors, the Repetitive Behavior Scale-Revised (Bodfish, Symons, Parker, & Lewis, 2000; Lam & Aman, 2007), whereas the present study used the ADOS and ADI-R, which capture repetitive behaviors more broadly; 2) Boyd and colleagues' measure of sensory processing collapsed items across multiple sensory modalities whereas the current study examined tactile processing in isolation; and 3) the age range of children in our sample was slightly older than that of the children reported on in Boyd and colleagues' sample. It would be interesting to know whether the patterns observed by Boyd et al. would shift when separated into distinct sensory modalities. Based on our results, we hypothesize that the tactile system might show different patterns than those observed in other modalities. If this is the case, the correlations observed by Boyd and colleagues might have been driven by relations with other sensory domains such as auditory or visual. This information would be useful in establishing modality-specific profiles relating sensory features to clinical symptoms in ASD.

Because of the recent study by Boyd et al., the prevalence of tactile hyper-responsiveness (defensiveness) in individuals with ASD, and autobiographical evidence that sensory hyper-responsiveness can drive social withdrawal (Gerland, 1997; Grandin, 1996), the lack of relations between tactile hyper-responsiveness and clinical symptoms of ASD in the present sample were surprising. It is possible that patterns of social withdrawal associated with sensory hyper-sensitivity or aversiveness represent the experiences of an interesting, but perhaps small, minority among individuals with ASD, whose sensory features and core symptoms are heterogeneous on the whole. Our relatively small sample size may have limited power to detect significant correlations in this subgroup. Alternatively, the use of diagnostic measures to quantify social, communicative, and repetitive behaviors may not have allowed us to tap into more nuanced elements of social interaction (e.g., no question on the ADI-R or ADOS assesses response to others' touch), which could be more directly impacted by tactile hyper-responsiveness.

Finally, repetitive behaviors have been posited to provide internally-controlled mechanisms for increasing perceptual constancy and maintaining a homeostatic state of arousal (Kinsborne, 1991; Rogers & Ozonoff, 2005). If the nervous systems of individuals with ASD fluctuate from under- to over-aroused, as proposed by Ornitz and Ritvo (1968), sensory behaviors may serve alternating functions in different scenarios. This hypothesis is consistent with the observation that individuals with ASD may show both hypo- and hyper-responsiveness to sensory input, even within a single modality. This complexity reinforces the need to conduct controlled, observational studies to begin to clarify in which situations and to which sources of input individuals with ASD show which patterns of responding. The inconsistency between our results and those of prior studies (Baranek et al., 1997; Boyd et al., 2010) may reflect this heterogeneity of arousal and responsiveness patterns, both within and across individuals with ASD.

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5. Conclusions

The approach taken by the present study has several strengths, including multi-method assessment of tactile processing and core symptomatology, using both direct observation and parent report measures, which add reliability and ecological validity, respectively. Our focus on a single sensory modality also allowed more fine-grained examination of the relations between sensory processing and core symptoms that might be obscured in studies collapsing across sensory modalities. In doing so, it yielded new information describing significant relations between tactile seeking and hypo-responsiveness behaviors, and social impairment and repetitive behaviors symptoms in ASD. The development of the somatosensory system in early infancy is hypothesized to be foundational for social and communication skills later in life (Dunbar, 1996) and thus may have a targeted influence on symptoms associated with ASD (Cascio, 2010). Future studies should explore the mechanisms by which tactile processing may relate to social impairment and repetitive behaviors, as well as compare sensory systems directly to clarify their relative relations with core symptoms of ASD. A better understanding of how atypical modality-specific (or more general) sensory behaviors may drive core social, communicative, and behavioral deficits associated with ASD will be an important step toward the development of improved therapeutic practices.

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Highlights

- A substantial proportion of children with autism spectrum disorder have sensory processing atypicalities, including unusual responses to tactile stimuli
- This study used both parent-report and direct-observation measures to evaluate tactile processing and core diagnostic symptoms
- Increased tactile seeking and hypo-responsive behaviors were associated with more severe social impairment and increased restricted and repetitive behaviors
- Tactile hyper-responsiveness, or defensiveness, was not found to relate to core social, communication, or behavioral symptoms in this sample
- Our findings of strong relations between tactile and diagnostic symptoms underscore the need for additional research on sensory processing in ASD

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Table 1

Participant characteristics.

	Mean ± SD	Range
Age		
Chronological age (mo.)	81.9 ± 10.0	61 – 96
Cognitive Functioning		
Mental Age (mo.)	58.0 ± 30.7	10.5 – 109.5
Developmental quotient	70.3 ± 36.0	11.8 – 136.0
ADOS Algorithm Domain and Summary Scores		
ADOS: Language/Communication	3.4 ± 1.4	1 – 6
ADOS: Reciprocal Social Interactions	10.3 ± 3.5	3 – 16
ADOS: Restricted and Repetitive Behaviors	4.5 ± 2.1	1 – 8
ADOS: Social Affect Total Score[a]	13.6 ± 4.0	4 – 20
ADI-R Algorithm Domain Scores		
ADI-R: Language/Communication	16.3 ± 4.7[b] [13.5 ± 0.8[c]]	6 – 24[b] [12 – 14[c]]
ADI-R: Reciprocal Social Interaction	19.1 ± 7.2	5 – 30
ADI-R: Restricted and Repetitive Behaviors	6.7 ± 2.3	3 – 11

[a]ADOS Social Affect Total score = sum of ADOS Communication and Reciprocal Social domain scores (Gotham et al., 2007);

[b]Sum of both verbal and non-verbal section for participants with adequate language (n=27);

[c]Sum of non-verbal sections only for participants with markedly limited expressive language skills (n=7).

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Table 2

Sensory measures and the tactile response patterns they assess.

		Tactile Response Patterns		
Sensory Measure	**Assessment Method**	**Seeking**	**Hypo-responsiveness**[a]	**Hyper-responsiveness**[b]
TDDT-R	Observational	√		√
SEQ	Parent report	√	√	√
Sensory Profile	Parent report		√	√

[a]Termed “high threshold” for response in the Sensory Profile;

[b]Termed “defensiveness” in the TDDT-R and “low threshold” in the Sensory Profile