Extreme Sensory Modulation Behaviors in Toddlers With Autism Spectrum Disorders

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- autism spectrum disorders (ASDs)
- behavior
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- sensory modulation

This study examined the incidence of extreme sensory modulation behaviors in toddlers with autism spectrum disorders (ASD) and investigated the consistency of sensory information across measures. Parent report of sensory behaviors in 101 toddlers with ASD was compared with 100 toddlers who were typically developing matched on chronological age and 99 additional infants or toddlers matched on mental age. Measures included the Infant/Toddler Sensory Profile, Infant–Toddler Social Emotional Assessment, Autism Diagnostic Interview–Revised, and Autism Diagnostic Observation Schedule–Generic. Toddlers with ASD were most distinct from typically developing groups in their high frequency of underresponsiveness and avoiding behaviors and their low frequency of seeking. Within the toddlers with ASD, there were significant associations across sensory parent report measures, but parent report was not correlated with clinical observation. Findings point to the early onset of an extreme sensory profile in ASD. Occupational therapists need to assess multiple domains of sensory behaviors to accurately identify the needs of toddlers with ASD.

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There is an ongoing debate regarding the universality and specificity of extreme sensory modulation behaviors in individuals with autism spectrum disorders (ASD) (O'Neill & Jones, 1997; Rogers & Ozonoff, 2005). Autobiographical accounts (e.g., Grandin, 1995; Jones, Quigney, & Huws, 2003) and behavioral studies describe the extreme nature of sensory patterns in individuals with ASD (e.g., Baranek, David, Poe, Stone, & Watson, 2006; Dunn, 2002; Ermer & Dunn, 1998; Kientz & Dunn, 1997; Liss, Saulnier, Fein, & Kinsbourne, 2006; Rogers, Hepburn, & Wehner, 2003; Tomchek & Dunn, 2007; Watling, Deitz, & White, 2001). Findings regarding rates and age at onset of extreme sensory behaviors in children with ASD have not been consistent, and investigators typically rely on a single measure, rather than multiple measures.

Sensory modulation is the ability to regulate and manage one's response to sensory input in a graded and adaptive manner (Mulligan, 2002). Sensory modulation patterns in children with ASD need to be studied because extreme patterns may interfere with effective learning, daily functioning (Dunn, 1997), and interactions (Ornitz, Guthrie, & Farley, 1978; Talay-Ongan & Wood, 2000). Based on Ayres's (1964, 1965) work, Dunn (1997) proposed a model in which sensory modulation is characterized by four patterns: (a) *sensory sensitivity*—distress and distraction from sensations, (b) *sensation avoiding*—controlling or limiting the amount and type of sensations, (c) *low registration*—lack or low awareness of sensations, and (d) *sensation seeking*—enjoyment and interest in increasing sensations. Both sensory sensitivity and sensation avoiding represent sensory overresponsiveness, whereas low registration and sensation seeking represent sensory underresponsiveness (Dunn, 1997). Similar to Dunn's model is a recent classification of

disorders of infants and toddlers by the Interdisciplinary Council on Developmental and Learning Disorders (ICDL Work Groups, 2005), which defines *sensory modulation disorder* as a type of sensory-processing regulatory disorder.

Evidence conflicts regarding the specificity of sensory overresponsiveness in children with ASD. Some studies report a higher frequency of sensory overresponsiveness behaviors in children with ASD compared with typically developing children matched on chronological age (CA) (Baranek et al., 2006; Dunn, Smith-Myles, & Orr, 2002) but not compared with children with developmental delays (Baranek et al., 2006). For example, Baranek et al. reported that 56% of children with ASD (from ages 2 to 7 years) showed extreme (more than 1 *SD* above norms) sensory overresponsiveness. Others have found that sensory sensitivity does not differentiate children with ASD from children who are typically developing (Ermer & Dunn, 1998; Watling et al., 2001) or from children with attention deficit hyperactivity disorder (ADHD) (Ermer & Dunn, 1998). Differences in age ranges, diagnostic criteria, and sample size may account for conflicting results.

Some researchers have suggested that sensory underresponsiveness is distinctive of children with ASD (Baranek et al., 2006; Rogers & Ozonoff, 2005). This claim was supported by evidence of a significantly higher frequency of underresponsive behaviors in children with ASD compared to typically developing children matched on CA (Baranek et al., 2006; Dunn, 2002; Dunn et al., 2002; Watling et al., 2001) and compared with mental age (MA) matched comparison groups (Baranek et al., 2006; Rogers et al., 2003). However, other studies did not find underresponsiveness to differentiate children with ASD from typically developing children matched on CA, children with ADHD (Ermer & Dunn, 1998), or children with Fragile X syndrome (Rogers et al., 2003). Baranek et al. found that 63% of children with ASD showed extreme sensory underresponsiveness, and 38% presented both extreme sensory underresponsiveness and overresponsiveness.

Of all sensory patterns, the least consistent evidence relates to sensation-seeking behaviors of toddlers with ASD. Using the Infant/Toddler Sensory Profile, Dunn (2002) did not find a difference in sensation-seeking scores of toddlers with pervasive developmental disorders (PDD) and toddlers who were developing typically. In contrast, Ermer and Dunn (1998) found that a lower incidence of seeking characterized children with ASD compared with children with ADHD and children who were developing typically. These findings are challenged by evidence of a higher incidence of sensation-seeking behaviors in children with ASD compared with children who are typically developing (Dunn et al., 2002; Watling et al., 2001). The differences between studies are surprising because findings are inconsistent even when the same measure is used (Ermer & Dunn, 1998; Watling et al., 2001). This inconsistency may relate to differences in the age range.

Discussion is ongoing as to whether extreme sensory behaviors qualify as a core autism deficit (Dunn et al., 2002; Ornitz et al., 1978; Rogers et al., 2003). Unusual sensory behaviors are described in gold-standard autism diagnostic measures (Lord, Rutter, & Le Couteur, 1994; Rutter, Le Couteur, & Lord, 2003) within the restrictive, repetitive, and stereotyped behaviors criteria but are not necessary for a diagnosis of ASD. In the Autism Diagnostic Interview–Revised (ADI–R) (Lord et al., 1994), unusual sensory interests were reported for 75% to 87% of toddlers with autism (Le Couteur et al., 1989; Lord, 1995). Moreover, unusual sensory behaviors have been observed in infants later diagnosed with autism (e.g., Zwaigenbaum et al., 2005).

Most studies compared the Sensory Profile scores of children with ASD to a CA-matched group (e.g., Dunn, 2002; Kientz & Dunn, 1997; Talay-Ongan & Wood, 2000; Tomchek & Dunn, 2007). The consideration of age-expected responses is important because changes were identified in seeking behaviors of children who were typically developing, ages 7 to 36 months, on the Infant/Toddler Sensory Profile (Dunn, 2002). An MA comparison group also is necessary because many children with autism show some degree of intellectual disability (American Psychiatric Association, 2000), and extreme sensory modulation patterns are prevalent in other clinical groups with low MA (e.g., Baranek et al., 2006; Rogers et al., 2003).

Methodological limitations in the reviewed studies include studying children across a wide age range (e.g., Liss et al., 2006; Miller, Reisman, McIntosh, & Simon, 2001; Talay-Ongan & Wood, 2000) and small sample sizes (i.e., fewer than 30 participants; e.g., Dunn, 2002; Miller et al., 2001; Rogers et al., 2003). Moreover, almost all studies focused on children with ASD who were older than age 3 years (e.g., Harrison & Hare, 2004; Pfeiffer, Kinnealey, Reed, & Herzberg, 2005; Smith-Myles et al., 2004). The present study was designed to address these limitations by studying sensory modulation behaviors in a large sample, focusing on a narrow age range in toddlerhood and including multiple measures and methods of evaluation to address the correspondence between parent report and clinical observation of sensory behaviors.

The following research questions were addressed: (a) Do toddlers with ASD differ in the frequency of sensory modulation behaviors from typically developing toddlers matched on CA or MA? (b) What is the association between the description of sensory behaviors of toddlers

with ASD across parent questionnaire, parent interview, and clinical observation?

Method

Participants

This study included 100 toddlers with a diagnosis of ASD and two typically developing comparison groups, one matched on CA and the other on MA. The ASD group had a mean CA of 28 months and a mean MA of 18 months based on the Mullen Scales of Early Learning (MSEL) Composite Score (Mullen, 1995). The ASD group included four sets of siblings, and 76% were boys (see Table 1 for child demographics). Most of the families lived in suburban settings and were primarily White and middle class. All children with ASD met criteria for autism or pervasive developmental disorder, not otherwise specified, on the ADI–R (Rutter et al., 2003) and the Autism Diagnostic Observational Schedule–Generic (ADOS–G) (Lord, Rutter, DiLavore, & Risi, 2002) and by the clinical impression of a doctoral-level clinical psychologist. Children with a physical disability or known genetic or neurological disorder (e.g., seizures) were excluded.

Two nonoverlapping comparison groups that were developing typically were randomly selected from the normative data collected by Dunn (2002), the author of the Infant/Toddler Sensory Profile. One group included 100 typically developing toddlers matched to the CA of the toddlers with ASD (referred to as the CA matched group). Mervis and Klein-Tasman (2004) stated that a *p* value greater than .50 should be used to say that the groups are matched rather than using the traditional *p* level of less than .05 to say that they do not differ. Therefore, the mean CA of the CA matched group was not significantly different from the CA of the ASD group at a *p* level greater than .50 as indicated by Tukey post hoc tests.

A second comparison group included 99 typically developing infants and toddlers matched to the MA of the ASD group (referred to as the MA-matched group). The MA of the ASD group was calculated by multiplying the Early Learning Composite score (obtained from the MSEL) by CA and dividing by 100. Tukey post-hoc tests demonstrated that the mean CA (CA was used as a proxy of the MA of the typically developing group) of the MA-matched group was not significantly different from the mean MA of the ASD group at a *p* level greater than .50 (Mervis & Klein-Tasman, 2004). Both comparison groups also were matched to the gender distribution of the ASD group.

Measures

Infant/Toddler Sensory Profile (ITSP) (Dunn, 2002). The ITSP is a 48-item caregiver questionnaire that measures sensory modulation abilities as reflected in daily experiences in children ages 7 months to 36 months. Parents rate the frequency of child behaviors on a 5-point scale from 1 (*almost always*) to 5 (*almost never*). The total frequency of behaviors is calculated for each sensory modulation section: Auditory, Visual, Vestibular, Tactile, and Oral Sensory. Scores are then grouped into four quadrant scores: Low Registration, Sensation Seeking, Sensory Sensitivity, and Sensation Avoiding. A low threshold score is calculated by summing Sensitivity and Avoiding quadrant scores. Lower scores indicate a higher frequency of response. Section scores and quadrant scores are interpreted relative to the age norms: (a) less than others and definitely different (> 2 *SD*), (b) less than others and probably different (1 *SD* to 2 *SD*), (c) typical performance (±1 *SD*), (d) more than others and probably different (–1 *SD* to –2 *SD*), and (e) more than others and definitely different (< –2 *SD*). Extreme scores

Table 1. Characteristics of the Children

Characteristics	ASD (*n* = 100)	CA Matched (*n* = 100)	MA Matched (*n* = 99)	Test Statistic	*df*	*p*
CA (in months)						
Mean (*SD*)	27.92$_a$ (4.01)	27.57$_a$ (3.93)	17. 57$_b$ (5.76)	F = 159.46	2, 296	.00
Range	18–33	20–33		7–35		
MA[c]						
Mean (*SD*)	17.76$_a$ (4.51)	27.57$_b$ (3.93)	17.57$_a$ (5.76)	F = 142.08	2, 295	.00
Range	10–36	20–33	7–35			
Gender						
Boy	76 (76%)	74 (74%)	74 (74.7%)	χ^2 = 0.11	2	.95
Girl	24 (24%)	26 (26%)	25 (25.3%)			
Race/ethnicity						
White	79 (79%)	82 (82%)	74 (74.7%)	χ^2 = 1.57	2	.46
Non-White	21 (21%)	18 (18%)	25 (25.3%)			

Note. ASD = autism spectrum disorders; CA = chronological age; MA = mental age.

[a, b] Groups with different subscripts differed significantly by Tukey post hoc comparisons.

[c] Chronological age of the typical groups was used as an estimate of their mental age, whereas mental age in the ASD group was based on the Mullen Scales of Early Learning (Mullen, 1995) composite score, which ranged from 49–113.

were defined as scores that were more than 1 *SD* above norms in frequency and are considered clinically meaningful. Reliabilities for the various composite scores ranged from .69 to .85. Test validity was established in several studies (Dunn, 2002; Dunn & Daniels, 2002; Kay, 2001). Of the ITSP data, 1.3% of items' scores was missing or rated as "No Opportunity" in the ASD group, and less than 0.01% in the CA- and MA-matched groups. Missing item scores were replaced with the mean of nonmissing quadrants' items when fewer than 20% of the items within a quadrant were missing. One toddler from the CA-matched group and one from the MA-matched group were excluded from the study due to missing data.

Autism Diagnostic Interview–Revised (Lord et al., 1994). The ADI–R is an investigator-based, semistructured informant interview for the diagnosis of ASD, appropriate for children with an MA of 18 months into adulthood. Items are coded from 0 (*no atypical behavior present*) to 2 (*definite abnormal behavior*). Occasionally, a code of 3 is used to indicate extremely atypical behavior. The accompanying algorithm focuses on three areas: communication, social, and restricted and repetitive behaviors. Cutoff scores for each area have been shown to adequately discriminate individuals with autism from an MA-matched comparison group without autism (Rutter et al., 2003). The measure yields acceptable internal consistency for each domain (Rutter et al., 2003).

In addition to using the ADI–R for diagnostic purposes, we examined frequencies on three sensory items from the Repetitive Behaviors domain: *Unusual sensory interests* (might share commonalities with ITSP Seeking), *Noise sensitivity,* and *Unusual negative sensitivity to sensory stimuli* (might share commonalities with ITSP Sensitivity). Out of the three, only the *Unusual sensory interests* score is included in the diagnostic algorithm if it is higher than other items in that section (Le Couteur et al., 2000). Of the ADI–R sensory scores, 2.3% were missing and were not replaced.

Autism Diagnostic Observation Schedule–Generic (Lord et al., 2002). The ADOS–G is a semistructured observation of children that measures social and communicative functioning in individuals suspected of having ASD. The ADOS–G has four modules, only one of which is given to each child, dependent on his or her age and language abilities. Most toddlers in this study were administered Module 1 (preverbal or single words); 4 toddlers were administered Module 2 (phrase speech). The assessment consists of social situations and probes designed to elicit behaviors relevant to a diagnosis of ASD. A diagnostic algorithm is computed from the social and communicative scores, resulting in a diagnosis of autism, ASD, or neither (Lord et al., 2002).

In addition to the use of the ADOS–G for diagnostic purposes, we described the *Unusual sensory interest in play materials/people* item (might share commonalities with ITSP Seeking and Sensitivity) from the restricted and repetitive behaviors domain. This item is scored from 0 (*no unusual interest*) to 2 (*definite interest in nonfunctional aspects of play materials or sensory examination of self or others, or persistent unusual sensory response to several sources*) on the basis of the child's behavior during the observation and is not included in the diagnostic algorithm (Lord et al., 2002). Lord et al. (2000) reported that interrater agreement for *Unusual sensory interests* in Modules 1 and 2 was above 80%.

Infant–Toddler Social and Emotional Assessment (Carter & Briggs-Gowan, 2006). The ITSEA is a parent report measure of social–emotional and behavioral problems and competencies in infants and toddlers. The measure consists of four domains (Internalizing, Externalizing, Dysregulation, and Competence). We examined the Sensory Sensitivity scale score from the Dysregulation domain. Parents rate their child's behavior from 0 (*not true/rarely*) to 2 (*very true/often*). Scale scores can be interpreted relative to the extreme 10th percentile cutoff point. The ITSEA has adequate psychometric properties, with acceptable test–retest and interrater reliability (Carter, Briggs-Gowan, Jones, & Little, 2003). Less than 0.01% of the ITSEA data was missing and was replaced with the mean scale score of nonmissing items.

Mullen Scales of Early Learning (Mullen, 1995). The MSEL provides a direct assessment of cognitive functioning in children from birth to age 68 months. It yields five scales (Fine Motor, Gross Motor, Visual Reception, Expressive Language, and Receptive Language) and an Early Learning Composite, a standard score that aggregates all scales but the Gross Motor scale.

Procedures

The data for this study were obtained from a larger study of trajectories of child and family functioning among families raising a toddler with ASD. After an initial phone screening, families were sent a booklet that included the ITSP (Dunn, 2002) and ITSEA (Carter & Briggs-Gowan, 2006). Also scheduled and completed were a parent visit, in which the ADI–R (Rutter et al., 2003) was administered at the child's home or at the laboratory, and a child visit, in which the MSEL (Mullen, 1995) and the ADOS-G (Lord et al., 2002) were administered in a laboratory setting.

The typically developing groups were recruited by Dunn (2002) and had only ITSP scores available. For the majority of toddlers across groups, we used questionnaires completed by mothers. For 3 toddlers with ASD and 5

typically developing children matched on MA, we used questionnaires completed by fathers, because either their fathers were considered the primary caregiver or more than half of their mother's items were missing.

Data Analysis

A few sensory scores were not normally distributed within each group based on Shapiro–Wilk normality tests; however, most scores had kurtosis and skewness scores between –1 and +1, suggesting that they were approaching normality. Because multivariate analysis of variance (MANOVA) is considered robust against normality violations (Stevens, 2002), we were confident in using this test. In addition, we repeated analyses using nonparametric Kruskal–Wallis tests and found the same results. MANOVA was conducted to analyze differences between groups in sensory quadrant scores. Fisher's exact tests were used to compare the rates of ITSP scores that differed from the norms between toddlers with ASD and each of the typically developing groups separately.

Results

Differences in Frequency of Sensory Modulation Behaviors

The first research question addressed group differences in the frequency of sensory behaviors. MANOVA revealed a significant group effect for ITSP sensory quadrant scores ($F(8, 582) = 50.43$, $p = .00$, $\eta_p^2 = .41$). Tukey posthoc tests showed that toddlers with ASD had significantly lower mean (higher frequency) ITSP Low Registration, Sensitivity, and Avoiding scores compared with both typically developing groups and had significantly higher mean (lower frequency) Seeking scores than the MA-matched group but not the CA-matched group (see Table 2).

We further examined whether a difference existed in the rates of extreme sensory behaviors. Figure 1 presents the rates of ITSP quadrant scores that were more than 1 *SD* and 2 *SD* above the norms in each group. Fisher's exact tests indicated that a significantly higher number of toddlers with ASD showed Low Registration, Sensitivity, and Avoiding scores that were more than 1 *SD* above norms compared with CA- and MA-matched groups ($p = .00$). A significantly lower percentage of toddlers with ASD showed Seeking scores that were more than 1 *SD* above the norms than did MA- and CA-matched groups ($p = .00$, $p = .04$, respectively). These findings indicate that the extreme nature of sensory responses of toddlers with ASD is characterized not only by relatively high frequencies of low registration and avoiding behaviors but also by lower frequencies of sensation-seeking behaviors.

Follow-up analyses examined differences between groups in showing extreme scores on multiple ITSP quadrants. Significantly more toddlers with ASD ($p = .00$) had at least two quadrant scores greater than 1 *SD* above the norms (69%) than did MA-matched (19.2%) and CA-matched (18%) groups. Chi-square tests showed that 67% of toddlers with ASD showed extreme scores simultaneously in Low Registration, Avoiding, and Sensitivity or in Low Registration and Avoiding, compared with 3% of CA-matched groups and 4% of MA-matched groups ($\chi^2 = 140.48$, $df = 2$, $p = .00$), suggesting that a subgroup of toddlers with ASD showed extreme sensory underresponsiveness and overresponsiveness, a pattern that was rare in the toddlers or infants that were typically developing.

Associations Between Sensory Measures in the Group With ASD

The second research question addressed the relation between different sensory scores of toddlers with ASD. Table 3 presents correlations among ITSP quadrants, ITSEA Sensitivity, ADI–R sensory scores, and ADOS–G sensory scores. The ADI–R Unusual Sensory Interests score was correlated with 3 ITSP quadrants. In contrast, the ADOS–G Unusual Sensory Interests score was associated only with the ADI–R Noise Sensitivity score and in the opposite direction than was expected.

Table 2. MANOVA Results for ITSP Sensory Quadrant Scores of Toddlers With and Without ASD

	Mean (*SD*)						
Quadrant	ASD	CA Matched	MA Matched	*F*	*P*	Power	Effect Size η_p^2
Low Registration	37.16_a (7.27)$_d$	49.97_b (4.32)	49.45_b (3.88)	180.68	.00	1	.55
Sensation Seeking	36.17_a (7.34)	33.70_a (8.35)	30.32_b (9.13)	12.33	.00	1	.08
Sensory Sensitivity	43.30_a (7.34)	46.57_b (5.40)	46.36_b (4.99)	9.24	.00	.97	.06
Sensation Avoiding	40.06_a (8.24)$_e$	50.58_b (5.65)	49.88_b (5.50)	79.17	.00	1	.35

Note. MANOVA = multivariate analysis of variance; ITSP = Infant/Toddler Sensory Profile (Dunn, 2002); ASD = autism spectrum disorders; CA = chronological age; MA = mental age. Each quadrant mean was based on a different number of items. Lower ITSP means indicate higher frequencies of behaviors. For all *F* statistics, *df* is 2, 295. η_p^2: partial eta-squared measure of effect size.

[a, b, c] Groups with different subscripts differed significantly by Tukey post-hoc comparisons.

[d] Mean is within the "definitely different" range, which is more than 2 *SD* above norms based on the mean CA of the group.

[e] Mean is within the "probably different" range, which is between 1 and 2 *SD* above norms based on mean CA of the group.

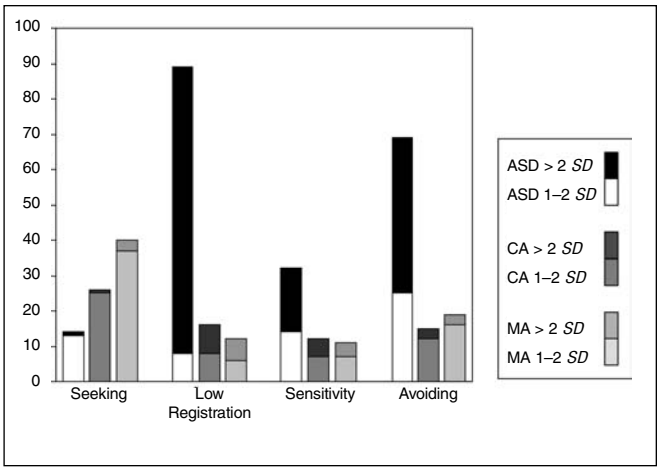

Figure 1. Rates of ITSP extreme quadrant scores by group.

Note. ITSP = Infant/Toddler Sensory Profile (Dunn, 2002); ASD = autism spectrum disorders; CA = chronological age; MA = mental age.

Discussion

This study investigated sensory modulation in toddlers with ASD relative to their CA and MA performance and examined the congruence of information among different sensory measures. Our primary findings were that (a) toddlers with ASD showed differences in all four ITSP quadrant scores compared with typically developing children matched for CA or MA; (b) low registration was the most prevalent extreme pattern, followed by avoiding; and (c) sensory information was consistent across parent report measures but not with clinical observation.

Rates and Nature of Extreme Sensory Behaviors

Although low registration was highly prevalent among toddlers with ASD (89%), only a few typically developing toddlers or infants showed extreme levels of low registration. The ITSP normative data distribution indicates that 16% of typically developing infants or toddlers scored within the "extreme" range of scores (more than 1 *SD* above norms), whereas 32% to 89% of toddlers with ASD scored in this range for low registration, avoiding, and sensitivity (Dunn, 2002). We argue that the high rate of low registration in toddlers with ASD relates to (a) their high rate of avoiding behaviors and (b) the social aspects of these behaviors. Low registration should not be evaluated in isolation from avoiding and sensitivity, because a sizable subgroup of toddlers with ASD (67%) had both extreme underresponsiveness and overresponsiveness, and low registration was moderately correlated with avoiding (r = .55). Possibly this mixed pattern reflects a common underlying mechanism in poor sensory modulation (Dunn, 1997). Alternatively, low registration behaviors may be an attempt to avoid and shut down from overstimulation (Lane, 2002). There is a need to study the shared mechanism of underresponsiveness and overresponsiveness and whether a certain level of response is context dependent.

In addition, the high incidence of low registration and avoiding may be understood in light of the social components described in these scales and the central social deficits observed in toddlers with ASD. Low Registration and Avoiding scales have the highest percentage of items (more than half) that include a social context or social aspects, several of which are comparable with symptoms of ASD (e.g., "avoids eye contact," "avoids playing with others") and describe communication processing (e.g., "ignores me when I am talking"). Sensory behaviors that involve a social context may be particularly challenging for toddlers with ASD because they involve multiple, simultaneous, and unpredictable stimuli. Several theoretical models attempt to explain the relation between sensory modulation and social deficits in ASD. Some propose that the negative sensory experience has cascading effects on social and

Table 3. Correlations Between Sensory Scores Across Measures Within ASD Group

	ITSP				ITSEA	ADI–R			ADOS–G
Sensory Scores	LR	SK	AV	SP-SE	EA-SE	ADI-SE	ADI-NS	ADI-USI	ADOS-USI
ITSP–Low Registration (LR)	—	.33**	.55**	.37**	–.24*	–.14	–.01	–.29*	–.18
ITSP–Seeking (SK)		—	.34**	.20*	–.15	–.01	–.11	–.34**	–.12
ITSP–Avoiding (AV)			—	.72**	–.57**	–.30**	–.14	–.26*	–.01
ITSP–Sensitivity (SP-SE)				—	–.69**	–.40**	–.31**	–.18	.12
ITSEA–Sensitivity (EA-SE)					—	.39**	.33**	.02	–.02
ADI–R–Negative Sensitivity (ADI-SE)						—	.34**	.07	–.03
ADI–R–Noise Sensitivity (ADI-NS)							—	.01	–.29**
ADI–R–Unusual Sensory Interests (ADI-USI)								—	.12
ADOS–G–Unusual Sensory Interests (ADOS-USI)									—

Note. ASD = autism spectrum disorders; ITSP = Infant/Toddler Sensory Profile (Dunn, 2002); ITSEA = Infant–Toddler Social and Emotional Assessment (Carter & Briggs-Gowan, 2006); ADI–R = Autism Diagnostic Interview–Revised (Rutter et al., 2003); ADOS–G = Autism Diagnostic Observational Schedule–Generic (Lord et al., 2002). Lower ITSP scores indicate higher frequency, lower ITSEA Sensitivity scores indicate lower frequency of behaviors, and lower ADI–R and ADOS–G scores indicate no presence or lower severity of behavior. All correlations with ADI–R and ADOS–G scores are nonparametric.

*p < .05; **p < .01.

communication development (e.g., Ornitz et al., 1978; Talay-Ongan & Wood, 2000). Others suggest that the social deficit in children with ASD limits the child's exposure to typical sensations, leading to sensory deprivation and secondary sensory deficits (Dawson et al., 2004).

The rate of sensory overresponsiveness in our sample was similar to that in Baranek et al. (2006), who looked at children from ages 2 to 7 years with ASD. Baranek and colleagues considered overresponsiveness as one construct, whereas we distinguished between sensitivity and avoiding, which Dunn (1997) considered as two types of overresponsiveness. We found that avoiding contributed more to the sensory overresponsiveness of toddlers with ASD than sensitivity, which was reflected in the higher rate of extreme avoiding behaviors and the larger effect size compared with sensitivity. This finding extends previous results that showed a greater involvement of avoiding versus sensitivity in the extreme sensory profile of children with ASD (Dunn, 2002; Dunn et al., 2002; Watling et al., 2001). Based on Dunn's (1997) description of sensory avoiding, it appears that toddlers with ASD tend to actively control and resist the perceived noxious sensations, perhaps to make sense of their experiences.

The rate of extreme low registration in toddlers with ASD in the present study (88%) was higher than previously reported (Baranek et al., 2006: ages 2–7 years; Ornitz et al., 1978: ages 1–6 years), possibly because of the younger and narrower age range of participants in our sample. Perhaps the frequency of low registration behaviors decreases over time as children gain coping skills and have more intervention. In addition, the inclusion of seeking behaviors within underresponsiveness in other studies (e.g., Baranek et al., 2006; Rogers et al., 2003) may have contributed to their lower rates because we did not find a high frequency of seeking behaviors but rather found a lower incidence than in children who were typically developing.

The lower incidence of extreme seeking behaviors on the ITSP is surprising given that stereotyped behaviors, which are a symptom of autism, also are a form of sensation seeking. This finding may reflect the young age of this sample, because children may show increases in stereotyped behaviors as they mature. Lower frequency of seeking in children with ASD also was identified by Ermer and Dunn (1998) but not in other Sensory Profile studies (Dunn, 2002; Watling et al., 2001). Seeking, as defined in the ITSP, represents interest in and attempt to increase sensory input, thus the lower incidence of extreme seeking may correspond with low registration (lack of interest) and avoiding (attempt to decrease sensation), which characterized toddlers with ASD in our sample. Alternatively this low frequency may relate to the ITSP describing frequency of typical seeking behaviors. This notion is supported by the high rates of unusual sensory interests of toddlers with ASD on the ADI–R and ADOS–G, suggesting that seeking of toddlers with ASD may not differ from typically developing toddlers in frequency but rather in quality.

Mental Age and Sensory Behaviors

Results suggest that MA was not a substantial moderator in the presentation of extreme sensory behaviors, strengthening the findings of Rogers et al. (2003) while contrasting with Baranek et al. (2006). This finding can be seen from the significant difference between toddlers with ASD and both typically developing groups in ITSP quadrant scores. The role of MA in the presentation of extreme sensory behaviors needs to be studied further, because MA matching in our study was limited by the use of CA as an estimate of MA in the typical group and by not matching on both CA and MA (Rogers & Ozonoff, 2005).

Consistency of Sensory Information Across Measures

Sensory information gained from different parent report measures in this study was associated, but not with sensory clinical observation of toddlers with ASD on the ADOS–G. Specifically, sensitivity scores were associated across parent measures, and Unusual Sensory Interests on the ADI–R was associated with ITSP quadrant scores. The ADI-R and ITSP may be comparable due to their distinction between sensory sensitivity and seeking scores rather than combining seeking and sensitivity into one sensory score as done in the ADOS–G. These results also may reflect similarities between parent report measures in their caregiver respondent, and in the daily context of the sensory behaviors described by parents. In contrast, the ADOS–G sensory score is based on limited clinical observation in a laboratory context.

Study Limitations and Future Research

Sensory scores from the diagnostic parent interview and observation were limited in detail because these were developed as components within diagnostic tests. The use of a detailed sensory parent interview and a clinical observation that are designed to evaluate multiple aspects of sensory modulation (including underresponsiveness) would be more comparable with the different constructs assessed in a sensory parent questionnaire. Finally, there is a need for documenting the performance of typically developing children on a sensory parent interview and in clinical observation.

Clinical Implications

The current study calls for early evaluation of sensory modulation in toddlers with ASD due to pronounced sensory

modulation deficits noted in this age group. Findings suggest that sensory modulation behaviors should be assessed using different types of measures that provide information across settings and from different perspectives. In addition, occupational therapists must use caution in interpreting high frequency of behaviors as indicative of impairment associated with the child's ASD, because there were low correlations between ITSP and ADI–R scores. In addition to assessing the relative frequency of sensory behaviors, researchers need to determine the individualized negative and positive impact of sensory behaviors on the child's and family's life. Social and sensory aspects of interactions are inevitably linked because social interactions require registration and response to sensory stimuli, and most sensory stimuli are presented by people or in the presence of people. We must understand how a child's sensory responsivity interacts with his or her social skills when designing services to address these issues.

Conclusions

This study confirms the early onset of extreme sensory modulation behaviors in toddlers with ASD, and the utility of the ITSP for differentiating toddlers with ASD from toddlers who are typically developing. The sensory profile that was most characteristic of toddlers with ASD was high frequency of low registration and avoiding behaviors. We hope that children with ASD will benefit from the translation of these results into earlier interdisciplinary evaluation of the impact of sensory symptoms on participation. ▲

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