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# Sensory Processing in Children With and Without Autism: A Comparative Study Using the Short Sensory Profile

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## KEY WORDS

- autism
- autism spectrum disorders (ASD)
- pediatric
- sensory integration
- sensory processing
- Short Sensory Profile (SSP)

**OBJECTIVE.** The purpose of this study is to investigate differences in sensory processing among age-matched children between ages 3 and 6 years with autism spectrum disorders (ASD) and those who are typically developing.

**METHOD.** Reported sensory processing abilities of 281 children with ASD were compared to age-matched peers who were typically developing, using the Short Sensory Profile (SSP).

**RESULTS.** Ninety-five percent of the sample of children with ASD demonstrated some degree of sensory processing dysfunction on the SSP Total Score, with the greatest differences reported on the Underresponsive/Seeks Sensation, Auditory Filtering, and Tactile Sensitivity sections. The ASD group also performed significantly differently ( $p < .001$ ) on 92% of the items, total score, and all sections of the SSP.

**CONCLUSION.** These findings, considered with similar published studies, begin to confirm the prevalence and types of sensory processing impairments in autism. Further research is needed to more clearly define patterns of sensory processing in people with ASD.

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Autism is a neurodevelopmental disorder characterized by qualitative impairments in social interaction and communication skill, along with a restricted repetitive and stereotyped pattern of behavior (American Psychiatric Association [APA], 2000). In addition to these core features of autism, researchers have reported that children and adolescents with autism spectrum disorders (ASD) respond to sensory experiences differently from peers without disabilities. These sensory processing disorders are well documented in the basic science literature (Ornitz, 1989; Ornitz, Lane, Sugiyama, & de Traversay, 1993; Yeung-Courchesne & Courchesne, 1997), clinical literature (Ermer & Dunn, 1998; Kientz & Dunn, 1997; Watling, Deitz, & White, 2001), and first-person accounts of living with autism (Cesaroni & Garber, 1991; Grandin, 1995). In fact, the initial appearance of these sensory processing findings often predates diagnosis (Adrien et al., 1993; Baranek, 1999; Dahlgren & Gillberg, 1989; Lord, 1995).

## Sensory Processing in ASD

The majority of evidence describing sensory processing disorders stems from parental reports, retrospective videotape analysis, and firsthand accounts of living with autism. Findings are limited to studies describing observable behaviors indicative of sensory processing patterns and do include studies investigating neurophysiological processes. To accurately reflect the significant number of studies describing sensory processing from multiple disciplines in addition to occupational

therapy, we use terminology that is consistent with the terminology used by the studies' authors, and, when possible, link the terms to current consensus terminology in sensory integration and practice (Miller, Lane, Cermak, Osten, & Anzalone, 2005).

### *Differences in Sensory Responding*

Impairments with modulating incoming sensory input have been widely reported in the literature describing autism characteristics (Adrien et al., 1987, 1992, 1993; Baranek, 1999; Dahlgren & Gillberg, 1989; Kientz & Dunn, 1997; Ornitz, 1989; Ornitz et al., 1993; Osterling & Dawson, 1994). These difficulties have also been reported by people with autism themselves (Cesaroni & Garber, 1991; Grandin, 1995). Incidence of sensory processing disorders reported in the autism literature range from 42% to 88% (Baranek, 2002; Kientz & Dunn, 1997; LeCouteur et al., 1989; Volkmar, Cohen, & Paul, 1986; Watling et al., 2001).

Differences in *auditory processing* are one of the more commonly reported sensory processing impairments with the full range of atypical responding noted. In one retrospective chart review of developmental patterns in 200 cases with autism, Greenspan and Weider (1997) reported that 100% of the participants demonstrated difficulties with auditory responding. Several authors have reported auditory hypersensitivity (Bettison, 1994; Dahlgren & Gillberg, 1989; Gillberg & Coleman, 1996; Rimland & Edelson, 1995; Vicker, 1993). Further, Dahlgren and Gillberg (1989) found that sensitivity to auditory stimuli in infancy was a powerful discriminator between children with and without autism. Other studies have reported auditory underresponsivity (Baranek, 1999; Osterling & Dawson, 1994; Wing, 1966). This hyporeactivity (e.g., diminished response to name) has been an early diagnostic consideration in that children who appeared to be deaf early in life have subsequently been diagnosed with autism (Wing, 1966).

Paradoxical *visual* responding also is reported in the literature. Avoidance of eye contact and inefficient use of eye gaze have been described as early social features of autism (Baranek, 1999; Gillberg & Coleman, 2000; Gillberg et al., 1990; Kientz & Dunn, 1997). Several authors (Dawson & Lew, 1989; Gillberg & Coleman, 2000; Gillberg et al., 1990; Miller, 1996; Wing, 1980) have theorized these features to be a self-regulatory mechanism that compensates for difficulties with modulating visual input. Other reports have noted that children with ASD often inspect objects (e.g., hands, moving objects) in an unusual way with their peripheral vision (LeCouteur et al., 1989; Lord, Rutter, & LeCouteur, 1994).

Overresponsivity to *tactile* input also has been reported in the literature (Baranek, Foster, & Berkson, 1997; Cesaroni & Garber, 1991; Grandin, 1995). In firsthand accounts,

touch has been described as an intense feeling that can be overwhelming and confusing (Cesaroni & Garber, 1991). Grandin (1995) noted that certain clothing textures could make her extremely anxious, distracted, and fidgety. Children with higher levels of tactile hypersensitivity in one study also were more likely to display inflexible behaviors, repetitive verbalizations, visual stereotypies, and abnormal focused attention (Baranek et al., 1997).

Attention and arousal impairments have been reported (Dawson & Lew, 1989; Ornitz, Guthrie, & Farley, 1977, 1978; Volkmar et al., 1986) and could be explained as relating to impairments in modulating sensory input. Early studies by Ornitz and colleagues (1977, 1978) described a pattern of disturbances in sensory modulation and motility having an impact on all sensory systems in more than 70% of the children younger than age 6 years with autism in their sample. Similar sensory findings have included no response to sound (81%), sensitivity to loud noises (53%), visual inspection of hands or fingers (62%), and arm flapping (52%) (Volkmar et al., 1986).

Sensory processing behaviors of children ages 3–6 years with ( $n = 40$ ) and without ( $n = 40$ ) autism, gathered via parent report on the Sensory Profile (SP; Dunn, 1999), also have been compared (Watling et al., 2001). Sensory processing of children with autism was significantly different from the sample without autism on 8 of 10 factors (Sensory Seeking, Emotionally Reactive, Low Endurance/Tone, Oral Sensitivity, Inattention/Distractibility, Poor Registration, Fine-Motor/Perceptual, and Other). Similarly, Mayes and Calhoun (1999) reported that 100% of children with autism ( $n = 143$ ) had 1 or more of the 10 symptoms in a somatosensory disturbance subscale (average of 6.2 symptoms) of an autism diagnostic screener. A love of movement, roughhouse play, and climbing (91%); atypical feeding patterns (75%); unresponsiveness to verbal input (71%); and unusual sensory inspection of objects (68%) were the most commonly reported items.

### *Discriminative Function of Sensory Processing*

Empirical data from clinical evaluations (Adrien et al., 1987; Gillberg et al., 1990), parent report measures (Dahlgren & Gillberg, 1989; Ermer & Dunn, 1998; Gillberg et al., 1990; Hoshino et al., 1982; Kientz & Dunn, 1997; Watling et al., 2001), and retrospective videotape analysis (Adrien et al., 1992, 1993; Baranek, 1999) are emerging to suggest that behavioral features of children with autism attributed to sensory processing differ qualitatively from children who are typically developing or those with other developmental disorders. These qualitative differences in sensory processing also have frequently been key features discriminating between these groups.

Adrien and colleagues (1987) used observations and frequency counts of behaviors during a structured play session to differentiate between children who were typically developing, children with mental retardation, and children with autism and very low developmental ages. Although many behaviors overlapped between the groups, 9 behaviors (rubbing surface, finger flicking, body rocking, repetitive jumping, decreased eye contact, limited or inappropriate social smile and laugh, using object ritualistically, ignoring objects, and absent response to stimuli) discriminated children with autism from both children who were typically developing and children with mental retardation. These findings were replicated by Rapin (1996), who found that atypical sensory modulation and motor stereotypies discriminated children with autism from children with other developmental disorders.

### *Parent Report*

Some data suggest that early sensory processing disorders noted on parent report measures or interview may be among the first signs of autism (Dahlgren & Gillberg, 1989; Gillberg et al., 1990; Hoshino et al., 1982). In an early study (Hoshino et al., 1982), infants with autism did not respond to certain sounds, were sensitive to the tastes of certain foods, and were insensitive to pain more frequently than infants who were typically developing or infants with other developmental disorders. More recently, sensory processing differences (i.e., overexcited when tickled, does not listen when spoken to, interested in looking at things that move, unusual eye gaze to objects, plays only with hard objects) reported retrospectively by parents discriminated between children with ASD and children who were typically developing younger than age 3 (Dahlgren & Gillberg, 1989; Gillberg et al., 1990). Further, whole body, hand and finger mannerisms, and unusual sensory interests (especially visual inspection of objects), as recorded on the Autism Diagnostic Interview, discriminated children with autism from those with other developmental delays (LeCouteur et al., 1989; Lord et al., 1994).

Some studies (Ermer & Dunn, 1998; Kientz & Dunn, 1997) have investigated sensory processing using the SP. Kientz and Dunn (1997) used scores on the SP, in its test development phase, to determine whether these scores discriminated between children with autism ( $n = 32$ ) and without autism ( $n = 64$ ). Multivariate analysis showed that children with ASD were reported to have higher rates of sensory processing dysfunction than the children without autism on all categories of the SP, with 84 of the 99 items (85%) differentiating the sensory processing skills of the groups. The items reflected both sensory modulation and praxis deficits in autism, as well as

the social and behavior characteristics often used in differential diagnosis.

In a follow-up study, Ermer and Dunn (1998) sought to determine which of the 9 factors on the SP best discriminated between children with ASD ( $n = 38$ ), children with attention deficit hyperactivity disorder (ADHD;  $n = 61$ ), and children without disabilities ( $n = 1,075$ ). The results yielded two discriminant functions: one that differentiated children with disabilities from those without disabilities and another that differentiated the two groups with disabilities from each other. Nearly 90% of the cases were classified correctly using these two functions. Specific to children with ASD, 4 of the 9 factors best discriminated: a low incidence of behaviors reported within the Sensory Seeking Factor, and a high incidence of behaviors noted within Oral Sensitivity, Inattention/Distractibility, and Fine Motor/Perceptual Factors.

A recent study (Rogers, Hepburn, & Wehner, 2003) assessed parent report of sensory reactivity of 102 young children across four groups: autism ( $n = 26$ ), Fragile X syndrome ( $n = 20$ ), developmental disabilities of mixed etiology ( $n = 32$ ), and children who were typically developing ( $n = 24$ ). All groups were comparable in socioeconomic status, ethnic status, and mental age. Clinical groups were also comparable in mean chronological ages. On the Short Sensory Profile (SSP; McIntosh, Miller, & Shyu, 1999), findings indicated that the groups of children with Fragile X syndrome and autism had significantly more sensory responses overall than the two comparison groups, although the children with autism did not differ significantly from children with Fragile X syndrome. Further, this abnormal sensory reactivity had a significant relationship with overall adaptive behavior.

### *Videotape Analysis*

Investigations also have used retrospective videotape analysis to explore early sensory and motor features of children later diagnosed with autism (Adrien et al., 1992, 1993; Baranek, 1999; Osterling & Dawson, 1994; Werner, Dawson, Osterling, & Dinno, 2000). Stereotypic behaviors, auditory underresponsiveness and overresponsiveness, unusual postures, and unstable visual attention were characteristic of infants later diagnosed with autism when compared to those with other developmental disorders or with children who were typically developing (Adrien et al., 1992, 1993).

Baranek (1999) used retrospective videotape analysis to explore the predictive capability of sensory and social behavior observations in children ages 9–12 months who were later diagnosed with autism. Here, sensorimotor features of social touch aversion and excessive mouthing of

objects, as well as delayed response to name and decreased affect rating, were subtle yet salient predictors at ages 9–12 months of a subsequent autism diagnosis and discriminated between children with autism ( $n = 11$ ), children with developmental disabilities ( $n = 10$ ), and children who were typically developing ( $n = 11$ ). In contrast, other researchers also using retrospective videotape analysis have not found early sensorimotor abnormalities in children with ASD (Osterling & Dawson, 1994; Werner et al., 2000).

The preceding review of sensory processing findings in ASD confirms the presence of sensory processing difficulties for most people at some point in development. What also should be evident is the lack of consistency among these studies in the size and ages of their samples, method(s) of measurement, and lack of replication. As a whole, sensory processing has received less attention in the literature than other developmental variables in autism (Baranek, 2002; National Research Council, 2001). As a result, findings have lacked consistency and likely reflect the variability in research questions and methods used in the studies. The purpose of this study was to investigate differences in sensory processing between age-matched preschool to early school-age children with ASD and those who were typically developing. The research questions were

1. What domains of sensory processing (e.g., tactile, auditory, oral–sensory, sensory seeking) are significantly different in this sample of children with ASD as measured by the SSP?

2. Do significant differences exist in sensory processing behavior identified in this group of children with ASD when compared to children who are typically developing?

## Methods

### *Participants*

*ASD group.* A retrospective chart review was used to compile data on the children diagnosed with ASD at a tertiary diagnostic center. Data used in this study represent existing clinical data; no new data were collected. People referred for evaluation because of suspected autism had received comprehensive medical, psychological, speech and language, and occupational therapy team evaluations. Clinical specialists in each discipline used test administration procedures, methods, and measurements appropriate to people on the autism spectrum; data from the assessment were included in this study. The ASD diagnosis was established by meeting the criteria on at least one of the following: Autism Diagnostic Interview–Revised (Lord et al., 1994); Autism Diagnostic Observation Schedule (Lord, Rutter, DiLavore, & Risi, 1999); or *DSM-IV-TR* criteria

(APA, 2000). A total of 400 participants with an ASD diagnosis were collected.

*Typically developing group.* This sample was taken from data collected for a national study (Dunn & Westman, 1997). The group consisted of 1,075 children from ages 3 to 10 years who were not receiving special education services or taking medications regularly.

*Participant matching.* The groups of participants were matched on chronological age and, when possible, gender. Complete matching on gender was not possible given the disproportionate male to female gender ratio seen in autism and in the total ASD group in this study. Therefore, the total sample ( $N = 562$ ) included 281 participants in each group with a mean age of 51.58 months (10.30 standard deviation). Specific to the ASD group, 256 had a diagnosis of autism (211 boys, 45 girls), 21 had pervasive developmental disorder, not otherwise specified (20 boys, 1 girl), and 4 had Asperger syndrome (all boys). In the typical group, 235 were boys and 43 were girls.

### *Instrumentation*

The primary variable in this study was reported behavioral sensory processing as measured by the SSP (McIntosh, Miller, & Shyu, 1999). The SSP is a 38-item caregiver report measure comprising the items that demonstrated the highest discriminative power of atypical sensory processing among all the items from the long version, the Sensory Profile (SP; Dunn, 1999). The full SP, from which the norms were established, was standardized on 1,200 children. Items are scored on a 1-point to 5-point scale. The 7 sections of the SSP found in a normative sample are Tactile Sensitivity, Taste/Smell Sensitivity, Movement Sensitivity, Under-responsive/Seeks Sensation, Auditory Filtering, Low Energy/Weak, and Visual/Auditory Sensitivity. Internal consistency of the sections within the scale ranged from .70 to .90 (Dunn, 1999). Internal validity correlations for the sections ranged from .25 to .76 and were all significant at  $p < .01$ . Both section scores and a Total Score are interpreted on the SSP and will be treated as the independent variables. The Total Score is the most sensitive indicator of sensory dysfunction.

Given its short administration time (10 min) and value in screening for atypical sensory processing, the SSP is recommended for research protocols (Dunn, 1999; McIntosh et al., 1999). In this study, the SSP is most appropriate because in the early phase of its development the social–communication and motor items in the SP were eliminated. Thus, the SSP isolates sensory processing that is less confounded by items overlapping with the diagnostic features of autism. Initial studies of the validity of the SSP have demonstrated discriminate validity of > 95% in

identifying children with and without sensory modulation difficulties (McIntosh et al., 1999). Miller and colleagues (2001) also correlated dysfunctional sensory processing scores with abnormal psychophysiological responses to a series of sensory challenges. Together, these findings provide initial support for use of the SSP as a valid measure of sensory processing.

### *Data Collection*

Children between ages 3 and 6 years who participated in an interdisciplinary diagnostic evaluation that resulted in an ASD diagnosis were located using a query of the scheduling and billing software. The query output was sorted by date of service and represented a registry of the potential sample for inclusion in this study. Chart review began with children evaluated most recently and worked back until 400 participants with complete SSPs (i.e., no blank items) were enrolled. Chart reviews and data entry directly into SPSS version 12.0 for Windows (SPSS, 2003) were completed by the first author.

### *Data Analysis*

Several analyses were conducted on the data set to characterize sensory processing and to investigate group differences. First, descriptive statistics were used. Item analysis identified items yielding the highest reported sensory processing dysfunction in this sample on the SSP. Percentages of performance on SSP sections for the samples by group for section summary classifications on the SSP were calculated. Second, multivariate analyses of variance (MANOVAs) were conducted to investigate differences in SSP items and sections between the groups. To be included in these analyses, caregivers had to have completed all items in a section. Complete SSPs were available on all 281 participants in the ASD group; however, in the typically developing group, caregivers occasionally rated items as not applicable. As a result, the section the item was contained in and the SSP Total Score could not be calculated. Therefore, complete SSPs were available on 221 participants in the typically developing group, with complete sections ranging from 254 to 278 participants.

## Results

### *Descriptive Statistics: Sensory Processing Performance on the SSP*

Reported performance classifications on the SSP for both groups are summarized in Table 1. On the SSP a *definite difference* indicates scores greater than 2 standard deviations from the mean for children who were typically developing

in the standardization sample, whereas a probable difference indicates scores greater than 1 and less than 2 standard deviations from the mean. Findings indicated that 83.6% ( $n = 235$ ) of the participants with ASD obtained definite difference scores in sensory processing for the SSP Total Score in comparison to 3.2% ( $n = 7$  of 221) in participants in the typically developing group. The ASD group scores exceeded the typical group in all definite difference section scores, with participants in the typically developing group consistently scoring more often in the typical performance range. Sensory processing sections of the SSP that yielded the highest reported definite differences in the ASD group included underresponsive/seeking sensation (86.1%,  $n = 242$ ), auditory filtering (77.6%,  $n = 218$ ), tactile sensitivity (60.9%,  $n = 171$ ), and taste and smell sensitivity (54.1%,  $n = 152$ ). Other SSP sections had somewhat lower percentages of reported sensory processing differences in the definite difference range but still a much higher percentage than the typically developing group. Notably, when *probable* and *definite* differences classifications were summed as an indicator of some degree of sensory processing differences, 95% ( $n = 267$ ) of the sample of children with ASD were rated as having some degree of difference in sensory processing based on the SSP Total Score (i.e., falling more than 1 standard deviation from the mean).

The preceding analysis of sensory processing sections provides some insight into sensory processing sections that yielded the highest reported differences. Table 2 presents percentages of children reported as *always* or *frequently* demonstrating the behaviors on the SSP, with items yielding a 50% or higher threshold in bold. Items were noted in the Tactile Sensitivity, Taste/Smell Sensitivity, Underresponsive/Seeks Sensation, Auditory Filtering, Visual/Auditory Sensitivity sections. The typically developing sample had no items that met the 50% criteria.

### *MANOVA: SSP Sections and Items by Group*

Using item raw scores, MANOVA findings indicated that participants in the ASD group performed differently from the participants in the typically developing group ( $p < .000$ ) in all SSP sections and for the Total Score (see Table 3). These comparisons yielded excellent power (.994–1.00) (i.e., there were enough participants to find differences between the groups). Small to moderate effect sizes (.219–.628; i.e., the differences are likely to be meaningful) were noted for Tactile Sensitivity, Taste/Smell Sensitivity, Underresponsive/Seeks Sensation, Auditory Filtering, and Visual/Auditory Sensitivity. Figure 1 shows the differences in section mean scores by group. Follow-up analysis indicated that there were significant differences ( $p < .001$ ) between the groups on 35 of the 38 items (92%), with

**Table 1. Performance Classification on the SSP Sections by Group**

Section	Typical Performance		Probable Difference		Definite Difference	
	ASD	Typical	ASD	Typical	ASD	Typical
Tactile Sensitivity	20.6%	75.6%	18.5%	15.5%	60.9%	8.9%
Taste/Smell Sensitivity	32.0%	84.5%	13.9%	8.7%	54.1%	6.8%
Movement Sensitivity	55.9%	71.6%	21.0%	21.6%	23.1%	6.8%
Underresponsive/Seeks Sensation	6.4%	74.9%	7.5%	19.1%	86.1%	6.0%
Auditory Filtering	7.8%	87.8%	14.6%	9.1%	77.6%	3.1%
Low Energy/Weak	58.0%	86.5%	18.9%	9.5%	23.1%	4.0%
Visual/Auditory Sensitivity	31.0%	77.3%	25.3%	17.8%	43.8%	4.8%
Total SSP	5.0%	83.3%	11.4%	13.6%	83.6%	3.2%

Note. ASD = autism spectrum disorders; SSP = Short Sensory Profile (McIntosh, Miller, & Shyu, 1999).

**Table 2. Percentages of Children Who Always or Frequently Displayed Behaviors on the Short Sensory Profile**

Item	% ASD	% Typically Developing
Tactile Sensitivity		
1. <b>Expresses distress during grooming</b>	<b>65.1</b>	13.0
2. Prefers long-sleeved clothing even when it is warm or short sleeves when it is cold	10.0	13.8
3. Avoids going barefoot, especially in grass or sand	13.2	1.8
4. Reacts emotionally or aggressively to touch	22.1	5.0
5. Withdraws from splashing water	13.5	3.2
6. Has difficulty standing in line or close to other people	41.6	6.5
7. Rubs or scratches out a spot that has been touched	13.9	2.3
Taste/Smell Sensitivity		
8. Avoids certain tastes or food smells that are typically part of children's diets	45.9	17.8
9. <b>Will only eat certain tastes</b>	<b>52.7</b>	7.4
10. Limits self to particular food textures/temperatures	45.6	5.8
11. <b>Picky eater, especially regarding food textures</b>	<b>56.2</b>	9.7
Movement Sensitivity		
12. Becomes anxious or distressed when feet leave the ground	8.2	1.4
13. Fears falling or heights	15.3	4.6
14. Dislikes activities where head is upside down	10.7	2.5
Underresponsive/Seeks Sensation		
15. <b>Enjoys strange noises/seeks to make noise for noise's sake</b>	<b>52.0</b>	17.3
16. <b>Seeks all kinds of movement and this interferes with daily routines</b>	<b>70.5</b>	2.2
17. <b>Becomes overly excitable during a movement activity</b>	<b>66.9</b>	19.1
18. <b>Touches people and objects</b>	<b>62.3</b>	3.2
19. Doesn't seem to notice when face and hands are messy	31.3	29.2
20. <b>Jumps from one activity to another so that it interferes with play</b>	<b>61.9</b>	1.4
21. Leaves clothing twisted on body	28.1	20.9
Auditory Filtering		
22. <b>Is distracted or has trouble functioning if there is a lot of noise around</b>	<b>58.0</b>	2.9
23. <b>Appears to not hear what you say</b>	<b>73.0</b>	4.3
24. Can't work with background noise	12.5	2.9
25. Has trouble completing tasks when the radio is on	16.4	2.7
26. <b>Doesn't respond when name is called but you know the child's hearing is OK</b>	<b>51.2</b>	1.8
27. <b>Has difficulty paying attention</b>	<b>79.0</b>	1.8
Low Energy/Weak		
28. Seems to have weak muscles	12.5	3.6
29. Tires easily, especially when standing or holding particular body positions	7.5	4.6
30. Has a weak grasp	11.4	2.1
31. Can't lift heavy objects	7.5	2.5
32. Props to support self	8.9	6.5
33. Poor endurance/tires easily	7.8	3.6
Visual/Auditory Sensitivity		
34. <b>Responds negatively to unexpected loud noises</b>	<b>50.9</b>	7.9
35. Holds hands over ears to protect ears from sound	45.6	11.9
36. Is bothered by bright lights after others have adapted to the light	16.0	1.1
37. Watches everyone when they move around the room	31.3	9.4
38. Covers eyes or squints to protect eyes from light	23.8	13.3

Note. Bold items are those with "always" or "frequently" reported behaviors by 50% or more of the caregivers of children with autism. ASD = autism spectrum disorders; SSP = Short Sensory Profile (McIntosh, Miller, & Shyu, 1999).

**Table 3. Group MANOVA *F* Values, Significance, Effect Size, and Power**

	<i>F</i> (1, 502)	<i>p</i>	Effect Size	Power
Tactile Sensitivity	305.07	.000	.379	1.000
Taste/Smell Sensitivity	239.06	.000	.323	1.000
Movement Sensitivity	20.13	.000	.039	.994
Underresponsive/Seeks Sensation	788.79	.000	.612	1.000
Auditory Filtering	845.86	.000	.628	1.000
Low Energy/Weak	61.04	.000	.109	1.000
Visual/Auditory Sensitivity	140.21	.000	.219	1.000
Total SSP	64.90	.000	.115	1.000

*Note.* Effect size as measured by eta square. MANOVA = multivariate analysis of variance; SSP = Short Sensory Profile (McIntosh, Miller, & Shyu, 1999).

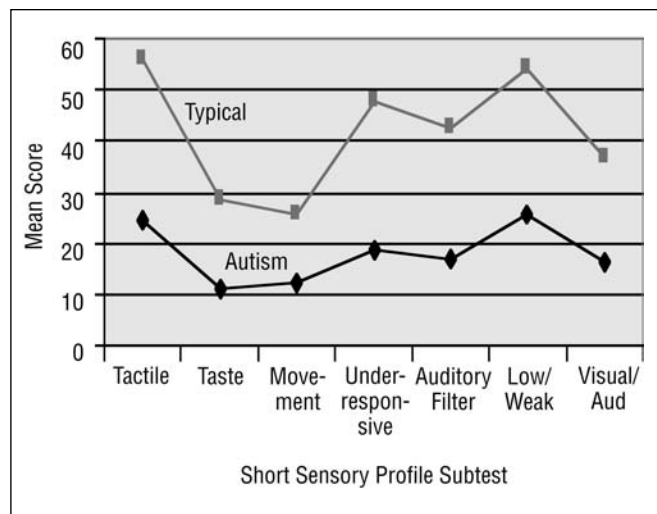
small to moderate effect sizes (.243–.652) and excellent power (.996–1.00). The only items not reaching the significance level were “prefers long-sleeved clothing even when it is warm or short sleeves when it is cold,” “dislikes activities where head is upside down,” and “covers eyes or squints to protect eyes from light.”

## Discussion

### *Sensory Processing Performance on the SSP*

The first research question asked whether sensory processing was different in this sample of children with ASD. Using the SSP Total Score as an overall indicator of sensory processing responses, children with ASD were often reported to have sensory processing impairments, whereas children in the typically developing group were not. Sensory processing section and item findings on the SSP reported in this study also are consistently elevated in studies involving children with ASD (Kientz & Dunn, 1997; Rogers et al., 2003; Watling et al., 2001). Using children from the same national sample who were typically developing, items yielding the highest frequency of dysfunctional sensory processing in independent groups of children with ASD were the same in the present study as those identified by Kientz and Dunn (1997). Although direct comparison of items in the other investigations is not possible given how data were reported, it should be noted that the items that make up the SSP sections (Rogers et al., 2003) and SP factors (Watling et al., 2001) that best discriminated children with autism contained these same high-frequency items. Together, these findings begin to elucidate consistent patterns of inattention/distractibility, sensory seeking, auditory sensitivity, and tactile sensitivity in children with ASD.

In this study, more than 90% of the ASD sample had significant differences in the Underresponsive/Seeks Sensation section. Analysis of section items indicated that the sample appeared to seek sensory input from multiple sensory systems (e.g., auditory, vestibular, tactile, propriocep-



**Figure 1. Mean scores by Short Sensory Profile Section by group.**

tion). A similar behavioral pattern was noted in other studies involving children with ASD (Kientz & Dunn, 1997; Rogers et al., 2003; Watling et al., 2001). These findings are in contrast, however, to the Ermer and Dunn study (1998) in which a low incidence of behaviors in the sensory-seeking factor was noted in a small group of children with ASD.

Sensory processing differences also were noted within the Auditory Filtering section among 77.6% of the sample. In general, children with autism in this sample appeared to tune out language (e.g., “appears to not hear what you say,” “doesn’t respond when name is called,” “has difficulty paying attention”), which to some degree also reflects the auditory processing deficits common in autism. These children also were noted to be distracted or to have trouble functioning if there was background noise. In contrast to the previously noted sensory seeking, in which children appeared to be actively seeking ways to regulate their behavior, children with these auditory sensitivities appeared to be more passive in relation to this input. These findings support previous research reports documenting similar auditory sensory responsivity patterns (Adrien et al., 1987; Baranek, 1999; Gillberg et al., 1990; Osterling & Dawson, 1994).

Tactile sensitivity difficulties noted in this study also are well documented in the autism literature that discusses sensory processing, especially in firsthand accounts of living with autism (Baranek et al., 1997; Cesaroni & Garber, 1991; Grandin, 1995). Tactile sensitivity symptoms occurred in this study among 60.9% of the ASD sample ( $n = 171$ ) in a difference classification, with the most reported difficulty tolerating grooming and hygiene tasks.

### *Comparison of Group Differences on the SSP*

A second research question asked whether group differences on SSP Total Score, sections, and items existed between

participants with ASD and typical controls. Consistent with previous reports of sensory processing in people with ASD (Kientz & Dunn, 1997; Rogers et al., 2003; Watling et al., 2001), current results indicated significant group differences. The participants in the ASD group performed differently from the participants in the typically developing group on all SSP sections and for the Total Score. Interestingly, as seen in Figure 1, the pattern of mean scores by section is similar between the groups, although the ASD group consistently demonstrated lower mean scores (indicating more frequent behaviors).

Furthermore, significant differences were noted between the groups on 35 of the 38 items (92%). The items that were most commonly reported in the ASD group were uncommon behaviors in the typically developing group. For instance, items relating to difficulty paying attention, appearing not to hear what you say, and movement seeking that yielded the highest frequencies in the ASD group were rarely reported in the typically developing group. Each of the 3 items not reaching significance represented a different SSP section and so may not reflect a general pattern but rather may indicate behaviors that are less relevant to ASD.

The group differences noted in this study may not, however, be unique to autism. Wing's (1966) initial writings noted impaired sensory responses across clinical groups of children. Rogers and colleagues (2003) confirmed these early behavior observations with similar patterns of sensory processing impairment reported in comparison groups of children with Fragile X syndrome and autism. In this study, auditory filtering and tactile sensitivity differences were reported in both the ASD and Fragile X groups, and although these groups did not differ significantly, both groups were more impaired than the other comparison groups of children who were developmentally delayed and children who were typically developing. Further, the results indicated that impaired sensory processing was associated with clinical diagnosis (either autism or Fragile X), although that did not differentiate these clinical groups. Here, high levels of repetitive behavior and the restricted behavioral repertoire were the best discriminators. A similar discriminant function was noted by Ermer and Dunn (1998). Their results, however, yielded two discriminant functions: one that differentiated children with disabilities from those without disabilities and another that differentiated two groups with disabilities (e.g., autism or ADHD) from each other. Together, these findings indicate that sensory processing disorders are often seen in children with disabilities, although they are not always unique to a specific disorder. They also highlight the discriminative power of sensory processing and the SSP in particular.

### *Implications for Practice*

Together, the sensory processing findings noted in this study reflect a pattern of dysfunctional sensory modulation; that is, children with ASD demonstrate difficulty with filtering and changing to sensory stimuli to develop an adaptive response. Sensory modulation has been defined as the capacity to regulate and organize the degree, intensity, and nature of responses to sensory input in a graded and adaptive manner (Miller & Lane, 2000). In turn, sensory modulation allows a person to achieve and maintain an optimal range of performance and to adapt to challenges in daily life.

The present study, like most previous studies, illustrates that sensory responses are significantly different for children who have ASD. Given the prevalence of these findings and their early onset, sensory processing disorders may represent another core diagnostic criterion for autism, a view that is supported by several authors (Coleman, 1976; Coleman & Gillberg, 1985; Gillberg & Coleman, 2000; Ornitz, 1989).

However, what also is important for practice is our ability to link these observations with challenges in participation. Sensory modulation impairments represent a mismatch between the external contextual demands of the child's environment and his or her internal characteristics (e.g., attention, emotion, sensory processing) (Miller et al., 2001) and can impair the ability of the child with autism to sustain engagement with people or in activities. Children with ASD in the present study, as in previous studies, have been found to be inattentive and distractible. In a small study, Fertel-Daly and colleagues (2001) found that providing touch pressure input through weighted vests enabled preschoolers with ASD to be less distractible and more attentive at school. More studies linking sensory-responding to participation are needed.

As previously noted, differences in sensory modulation among people with autism have been well documented in the literature, and the findings in this study add to the evidence. Sensory processing skills are fundamental to functional performance and therefore likely play a role in the variable developmental performance of people with ASD (Baranek, 2002). Recognizing these sensory processing contributions as a vital component of the complex developmental presentation of people with ASD provides direction for intervention planning and highlights the importance of occupational therapy practice in facilitating engagement in occupations.

### *Study Limitations and Future Research Directions*

The major limitation of this study was the use of a convenience sample of people with ASD from one region of the



country. Further, sensory responses were considered only in the context of behavioral observations via a parent report measure and not in direct observation. To validate the SSP, additional studies linking sensory response behaviors with neurophysiological evidence are needed.

The findings of this study with a large sample of people with ASD, considered with previous research investigating sensory processing in autism, establish clear trends showing differences in sensory responses between children with and without ASD. Although this question of differentiation between children with and without autism is an important one, this line of research will describe only the prevalence and types of sensory processing disorders within this single population. It fails, however, to establish the relationships among these sensory responses and core diagnostic features or other developmental variables in autism. Further research is needed to investigate the relevance of sensory processing aspects on the variable developmental presentation and occupational performance of people with ASD. Therefore, studies with large samples that yield statistical power are needed so that researchers can conduct factor and path analyses to identify clusters of observations that link sensory processing responses and functional behaviors. The findings also may differentiate groups of people with autism by sensorimotor pattern to investigate differential responding to various interventions (Huebner & Dunn, 2001).

Beyond autism, future research investigating differences in sensory responses across clinical groups appears warranted to more clearly define the sensory processing patterns unique to each disorder as a mechanism for better understanding these disorders, which in turn will guide intervention. Doing so not only will allow for identification of discriminating sensory processing factors by diagnosis, but also may validate the sensory processing taxonomy (Miller et al., 2005).

## Conclusions

The majority of children with ASD in this sample were reported to have difficulties with processing and responding to sensory input on the SSP. Ninety-five percent of the sample demonstrated some degree of sensory processing dysfunction on the SSP Total Score. Children were reported to be inattentive, underresponsive, and sensitive to tactile input. They also were reported to seek sensory input and to have difficulty filtering auditory input. The ASD group also performed significantly differently on 92% (35 of 38) of the individual items; a total score and scores for all sections of the SSP were likewise significantly different when children

with autism were compared to age-matched peers who were typically developing. These present findings, considered with similar studies reported in the literature, begin to confirm the presence of sensory processing disorders in children with ASD and begin to unravel the types. Further research is needed to more clearly define patterns of sensory processing in people with ASD and to investigate the relationships of these patterns on the occupational performance of children from this population. ▲

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