Pilot Study of the Sensory Over-Responsivity Scales: Assessment and Inventory

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KEY WORDS
- adults
- assessment
- diagnosis-related groups
- pediatrics
- sensory disorders
- sensory modulation

This article describes 3 stages of construction of the Sensory Over-Responsivity (SensOR) Scales: instrument development, reliability and validity analyses, and cross-validation on a new sample. The SensOR Scales include the SensOR Assessment, an examiner-administered performance evaluation, and the SensOR Inventory, a caregiver self-rating scale. Both scales measure sensory overresponsivity in 7 sensory domains. Data were collected from 2 samples consisting of participants who were typically developing (*n*s = 60 and 44, respectively) and participants with sensory overresponsivity (*n*s = 65 and 48, respectively), ages 3 to 55. In developing the research edition, items on the pilot version were reviewed for their internal consistency reliability, discriminant validity, and construct validity. Data from both samples on the research edition revealed high internal consistency reliability for domains and the total test and significant discrimination between the overresponsive and the typically responsive groups ($p < .05$). The preliminary psychometric integrity of the scales, along with continued research efforts, is an important contribution to evidence-based practice.

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Sensory modulation disorder has been discussed in the occupational therapy literature for more than 40 years (Ayres, 1964). Empirical validation for the condition's diagnostic validity, however, is sparse, in part because of the lack of an objective performance measure to identify the disorder in children and adults. In general, identification of people with sensory modulation disorder and referral for occupational therapy are based on clinical observations, self-report or caregiver reports, and developmental and sensory history (Dunn, 1999; Johnson-Ecker & Parham, 2000). Recent advances in physiologic methods have suggested that these methods have promise for the accurate identification of sensory modulation disorder (Mangeot et al., 2001; McIntosh, Miller, Shyu, & Hagerman, 1999; Miller et al., 1999; Schaaf, Miller, Seawell, & O'Keefe, 2003); however, the existing performance evaluation methods screen only for sensory modulation disorder. Thus, development of a diagnostic evaluation of sensory modulation disorder for practicing clinicians is needed.

Recently, the scientific community has emphasized the importance of evidence-based approaches so that decisions are based on objective data rather than on clinical experience and belief systems. The sociopolitical climate related to shrinking health care resources mandates the use of assessment procedures that have demonstrated reliability and validity (Christiansen & Lou, 2001; Holm, 2000). Occupational therapy, in particular, has a significant need for reliable and valid instruments (Dysart & Tomlin, 2002) to increase the accuracy of diagnostic decisions and verify the need for treatment referrals.

Ayres (1964) was the first to acknowledge sensory modulation difficulties as an identifiable dimension in children with disabilities. She provided a detailed clinical description of what she called tactile defensiveness or overresponsivity in the tactile system. She later identified gravitational insecurity and abnormal autonomic responses to movement as additional indicators of sensory overresponsivity affecting the vestibular system (Ayres, 1972a, 1972b, 1979). These constructs were later expanded to include a common triad of overresponsivity in three sensory systems—the olfactory, tactile, and auditory systems—that became known as *sensory defensiveness* (Knickerbocker, 1980; Wilbarger & Wilbarger, 1991). Unfortunately, empirical information about the concept of tactile overresponsivity (defensiveness) and its relation to other types of sensory overresponsivity is limited.

Other researchers have elaborated on the construct of overresponsivity in young children (Bar-Shalita, Goldstand, Han-Markowitz, & Parush, 2005; Provost & Oetter, 1993), specifically within the tactile domain (Royeen, 1985, 1986; Royeen & Fortune, 1990) and among different clinical populations (Baranek & Berkson, 1994; Kinnealey, 1973; Pfeiffer, Kinnealey, Reed, & Herzberg, 2005). Sensory overresponsivity is conceptualized in Dunn's (1997) model by two behavioral response continua, *sensory sensitive* and *sensory avoiding.* People who are sensory sensitive are described as fearful and cautious or negative and defiant, whereas people who are sensory avoiding seek to withdraw from or reduce their experience of the uncomfortable sensory stimuli. This model addresses sensory modulation across sensory systems rather than within discrete systems. An examination of sensory modulation disorder by discrete sensory domains can facilitate the development and implementation of domain-specific interventions (Johnson-Ecker & Parham, 2000; Royeen & Mu, 2003).

In an effort to create a uniform terminology for research purposes, Miller, Cermak, Lane, Anzalone, and Koomar (2004) proposed three subtypes for children with sensory modulation disorder: (1) sensory overresponsivity (defined later), (2) sensory underresponsivity, and (3) sensory seeking. This terminology was recently incorporated into the *Interdisciplinary Council for Developmental and Learning Disorders: Diagnostic Manual* (Interdisciplinary Council for Developmental and Learning Disorders [ICDL], 2005) and the *Diagnostic Classification: 0-3–Revised* (Zero to Three, 2005). Miller et al. (2004) proposed *sensory overresponsivity* as a new label for a combination of sensory defensiveness and increased sensory sensitivity within discrete sensory systems. This term subsumes defensiveness, hypersensitivity, and aversive responses to sensory input. Of the vast array of behaviors included in sensory processing disorder, sensory overresponsivity is a logical starting point for empirical validation and advocacy for inclusion in additional diagnostic taxonomies such as the *Diagnostic and Statistical Manual of Mental Disorders* (American Psychiatric Association, 2000) because the behaviors are readily observable.

People with sensory overresponsivity exhibit exaggerated responses to one or more types of sensory stimuli not perceived as threatening, harmful, or noxious by children and adults who are typically developing. The fight, flight, or freeze reactions manifested by people who are overresponsive have been associated with anxiety (Kinnealey & Fuiek, 1999; Kinnealey, Oliver, & Wilbarger, 1995), hyperactivity and inattention (Parush, Sohmer, Steinberg, & Kaitz, 1997), and interference with engagement in social interactions and participation in home and school routines (Cohn, Miller, & Tickle-Degnen, 2000; Lane, 2002). Tactile and auditory overresponsivity are the most common domains of sensory overresponsivity studied and are reported to affect the ability to perform everyday activities (Bauer, 1977; Larson, 1982; Royeen, 1986; Royeen & Fortune, 1990).

Recent research has suggested that problems in sensory processing are quite common. In a recent population-based study of a Colorado school district, 5% of the kindergarteners demonstrated significant symptoms of sensory modulation disorder (Ahn, Miller, Milberger, & McIntosh, 2004). The raw data were reanalyzed by the authors of this article to evaluate the incidence of sensory overresponsivity by excluding items that measured other aspects of sensory processing. (Note that the second author of the prevalence study is the second author of this article.) Prevalence rates of sensory overresponsivity varied from 2.8% to 6.5% across tactile, movement, visual–auditory, and taste–smell domains. Similar prevalence rates for sensory overresponsivity were obtained in a study of a community sample of twins (Goldsmith, Van Hulle, Arneson, Schreiber, & Gernsbacher, 2006).

The most commonly used standardized caregiver or self-questionnaires are the Sensory Profile Scales for various ages (Brown, Tollefson, Dunn, Cromwell, & Filion, 2001; Dunn, 1994, 1999; Dunn & Brown, 1997). Interpretation of the sensory impairments evaluated by the Sensory Profile Scales (Dunn, 1999), however, is complicated by the inclusion of emotional and fine motor items in addition to sensory processing items, and it is clouded by the fact that more than 50% of the items do not group in a principal-components factor analysis (Dunn & Brown, 1997) and that no standard scores are derived.

A review of existing scales for sensory overresponsivity suggests that all existing scales have limitations. The primary limitations include the following: (1) not administered directly to participant but rather depend only on caregiver or self-report; (2) conceptually too broad, attempting to characterize all sensory processing problems with one scale; (3) conceptually too narrow, reflecting overresponsivity in only one sensory domain; (4) designed for a limited age group; and (5) lack of normative information or reliability and validity studies.

The literature suggests that direct observation by a trained professional can contribute to a more reliable and predictive assessment when used in combination with caregiver- or self-report scales (Achenbach & Rescorla, 2004; Baranek, 1998; Baranek & Berkson, 1994; Baranek, Foster, & Berkson, 1997). Therefore, the use of a performance measure in which scores are based on direct observation of the client by the professional is considered important to a thorough, accurate assessment (Achenbach & Rescorla, 2004).

A few studies of sensory overresponsivity using direct observation exist in the occupational therapy literature, although those studies did not result in assessments that therapists could use. One early attempt involved the development of a checklist that categorized clinical observations of responses to tactile stimulation (Bauer, 1977). Another scale was piloted with children who had severe cognitive deficits (Kinnealey, 1973). A more recent behavioral assessment, the Tactile Defensiveness and Discrimination Test (Baranek, 1998), was designed for children with developmental disabilities and measures overresponsivity in only one sensory system (Baranek, 1998). Neither the Kinnealey (1973) nor the Baranek (1998) study reported standardized procedures or data from a normative sample. Thus, a new evaluation system that includes both a caregiver report and a performance measure of multiple domains of sensory functioning with adequate reliability and validity is needed to objectively evaluate sensory overresponsivity.

Method

We constructed a measure of sensory overresponsivity and evaluated its psychometric characteristics. The project included three stages. Stage 1, the instrument development stage, produced a pilot version of both the performance assessment and the rating scale. After item analysis, this stage resulted in the development of a new edition of both scales, which we call the *research edition* of the Sensory Over-Responsivity (SensOR) Assessment and Inventory scales. Stage 2 evaluated the reliability and validity of the research edition by analyzing the scales' internal consistency and construct validity with Sample 1. Stage 3 addressed the need to cross-validate findings by examining the research edition's reliability and validity in a second sample.

Participants

We recruited two separate samples. Sample 1 participated in Stage 1 and Stage 2, the development of the pilot versions and the reliability and validity studies of the research edition. Sample 2 participated in Stage 3, the cross-validation of reliability and validity of the research edition.

Stages 1 and 2. Sample 1's participants consisted of 125 people between ages 3 and 55. Sixty were typically developing, and 65 were referred with symptoms of sensory overresponsivity.

Identification of the sensory overresponsive sample. The 65 participants with sensory overresponsivity were identified through extensive clinical evaluation by an experienced occupational therapist considered to be a master clinician (>15 years of clinical practice). Therapists clinically identified sensory overresponsive participants on the basis of global assessments of functioning and were unaware of the SensOR Assessment and Inventory items. The only criterion for inclusion was the presence of overresponsivity in one or more sensory domains that the therapist felt interfered significantly with daily life activity. The Short Sensory Profile (SSP; McIntosh, Miller, Shyu, & Dunn, 1999) or the Adult Sensory Profile (ASP; Brown & Dunn, 2002) was administered after the therapist referred the participant to the study to confirm his or her classification in the sensory overresponsivity group. Participants who endorsed a majority of sensory overresponsive items in one or more sensory domains on the Sensory Profile Scales were retained in the sample. No participants were excluded on the basis of their SSP or ASP score.

Identification of the typically developing sample. A telephone interview was conducted to recruit the 60 participants without sensory overresponsivity. Each site recruited a convenience sample of typically developing people and used the telephone interview questions to confirm the lack of sensory overresponsivity. Inclusion criteria included no history of unusual sensory sensitivity; no birth risk factors (e.g., prematurity, neonatal intensive care unit stay, low birth weight); no previous neurological, psychiatric, developmental, behavioral, or learning disability diagnoses; no history of school difficulty or involvement in therapeutic intervention; and not taking regular prescription medications.

The typically developing group was stratified by age, gender, and ethnicity (e.g., participants were group matched on demographic variables but were not control matched in a pairwise fashion). No significant group differences were found between typically developing and overresponsive groups on age, gender, or ethnicity.

Stage 3. We recruited a second sample, with no overlapping participants from the previous studies, for Stage 3. Sample 2 consisted of 44 typically developing people and 48 people with symptoms of sensory overresponsivity; the age range was 4 to 55 years. Procedures for inclusion and inclusion criteria and group matching for typically developing participants were the same as described for Sample 1. None of the participants who had sensory overresponsiveness in the second sample had comorbid diagnoses. This sample also had no significant within-group differences on age, gender, or ethnicity.

Procedures

The SensOR Scales consist of (1) the SensOR Assessment, an examiner-administered performance scale, and (2) the SensOR Inventory, a caregiver–self-rating scale. Stage 1, the instrument development phase, began with a thorough review of the related theoretical literature. More than 60 references were used to support item selection. Included were textbooks (Bundy, Lane, Fisher, & Murray, 2002; Roley, Blanche, & Schaaf, 2001), key peer-reviewed articles (Bauer, 1977; Dunn, 1997; Kinnealey et al., 1995; Larson, 1982), related chapters (Dunn, 1997; Parham & Mailloux, 2001; Walker, 1993), and existing scales (Ayres, 1989; Baranek, 1998; Brown & Dunn, 2002; DeGangi & Balzer-Martin, 2000; DeGangi & Poisson, 2000; Dunn, 1999; Dunn & Daniels, 2000; Parham & Johnson-Ecker, 2002; Provost & Oetter, 1993; Royeen, 1987; Royeen & Fortune, 1990).

Next, we developed preliminary versions of the SensOR Assessment and the SensOR Inventory, organized by sensory domain. Each domain of the SensOR Assessment includes subtests (activities similar to daily occurrences) consisting of clusters of items. The SensOR Inventory's format parallels that of the SensOR Assessment, with items clustered within sensory domains to be rated by a respondent (self or parent). We developed a rating system for the SensOR Assessment to address both physical and verbal expressions of discomfort indicating sensitivity to the sensory stimuli during the testing. Standard instructions for administration and scoring were developed, and a test kit was compiled.

A content validity study was undertaken by two expert panels to evaluate selection of activities and wording of items. These focus groups included 20 master occupational therapy clinicians. Using an informal Delphi structure, researchers and clinicians rated each item on the SensOR Assessment and SensOR Inventory. We revised the scales on the basis of expert feedback, retaining the best set of nonoverlapping items for each scale that represented functional aspects of sensory overresponsivity occurring during daily life activities and routines.

The SensOR Assessment and SensOR Inventory were administered to 5 children to determine the feasibility of the items and to field test the mechanics of administration. The scoring system, test administration, and record forms were revised to create the pilot version of the scales. The manual was finalized, and a videotape was created for training testers.

The pilot version of the SensOR Assessment was a performance measure representing the seven sensory domains; it consisted of 90 items divided into 21 subtests. For example, 1 auditory subtest was an audiotape of sounds (e.g., police sirens and vacuum cleaners that typically elicit overresponsivity).

The scoring of the pilot version of the SensOR Assessment was a count of the overresponsive behaviors in six behavioral categories. Operational definitions for each behavioral category were included in the manual as well as a sample list of behaviors that might be observed in each category to aid consistency of scoring. The behavioral categories were *startle,* an immediate physical response indicating extreme surprise; *dislike,* a subtle physical response indicating discomfort, such as facial grimacing or continuous blinking; *elimination,* a physical response attempting to neutralize the stimulus such as rubbing the skin after light touch or covering the ears to sounds; *refusal,* a physical response of outright withdrawal to participate; *aggressiveness or activity,* an antagonistic physical response or significant increase in activity level; and *negative–stop,* negative verbal comments indicating a desire to disengage or outright requests to stop. For each item, the examiner endorsed the appropriate behavioral category. The child's score was the number of overresponsive behaviors for each subtest; we also compiled sensory domain scores.

The pilot version of the SensOR Inventory consisted of 143 items in 16 stem questions that described aspects of daily life, such as "These aspects of self-care bother me: washing or wiping face, having haircut, or getting dressed" and "These sounds bother me: door bell ringing, dog barking, construction, or landscaping equipment." The SensOR Inventory scores were binary (applicable or not applicable), with each item receiving a total score of 0 or 1. The child's total score was the total number of overresponsive behaviors endorsed by parent or self (older than age 16), and subtest scores were compiled for each sensory domain.

Validation Instrumentation. The SSP is a short version of the Sensory Profile Scales (Dunn, 1999), a sensory questionnaire designed to measure responses of children, ages 3 to 16, to sensory experiences during everyday activities. The reliability and validity of the SSP are strong (McIntosh, Miller, Shyu, & Dunn, 1999).

The ASP is a sensory questionnaire targeting the responses of adolescents and adults, ages 17 to 65, to sensory experiences in daily life. Moderate reliability and construct validity are reported (Brown et al., 2001; Brown & Dunn, 2002).

Data Collection. We provided information about standard procedures to six collaborating sites, professionals who are members of the Sensory Processing Disorder Scientific Workgroup (www.kidfoundation.org/research), who recruited participants with and without sensory overresponsivity. Written informed consent was obtained from all parents (and assent from children older than 7 years) before participation in the study.

The testing was conducted under workgroup member supervision at the testing sites nationwide. Testers were trained by watching a videotape we prepared and through careful self-testing using criteria in the manual. Test mechanics and scoring questions were addressed in ongoing consultation with us. However, testers were not unaware of participants' group assignment.

Data for all stages were collected over a 5-month period by the primary examiner at each collaborating site. Test administration was conducted in a quiet, nondistracting room and lasted approximately 1 hr per participant. Adult participants or parents of child participants completed (1) a demographic form, (2) the SSP (McIntosh, Miller, Shyu, & Dunn, 1999) for those ages 3 to 16 or the ASP for those ages 17 and older (Brown & Dunn, 2002), and (3) the SensOR Inventory. The SensOR Assessment was administered and scored by a trained examiner.

Data Analyses

Stage 1: Instrument Development. Data analyses were performed on the pilot version of the SensOR Scales to identify the optimal set of items for inclusion in the research edition. Analyses emphasized item characteristics, including item total correlation, the relationship of each item to the subtest total, and the discriminant validity of items, comparing the performance of the typically developing and sensory overresponsive groups.

We assessed construct validity with an exploratory principal-components analysis to determine the dimensionality of the data, using an orthogonally rotated component matrix. To check the robustness of the factor structure, the samples with and without sensory overresponsiveness were factored separately.

Pragmatic validity was provided throughout the study. The utility and appropriateness of the rating system for the performance assessment was evaluated by feedback from testers. Frequency of use for each scoring category informed item retention. Each participating site provided specific information about how the items discriminated clinically and their ease of administration.

At the conclusion of these analyses, we constructed a new version of the SensOR Scales, called the research edition.

Stages 2 and 3: Reliability and Validity of the SensOR Research Edition. We examined the internal consistency reliability for each sensory domain. Discriminant validity determined the degree to which each sensory domain differentiated between participants with and without sensory overresponsivity. All analyses were conducted on Sample 1 and Sample 2.

Results

Stage 1: Instrument Development

Item Pool Reduction. On the basis of the results of the item analyses, we reduced the item pool of the pilot version of the SensOR Scales. Items were eliminated if they demonstrated either (1) low correlations with the subtest or with the domain scores (i.e., reduction of internal consistency reliability coefficients of the subtest or domain to <.60) or (2) nonsignificant discrimination between the groups with and without sensory overresponsivity ($t[123] < 2.0, p > .05$).

Item Scoring Category Simplification for the SensOR Assessment. The SensOR Assessment scores are a count of the number of overresponsive behaviors observed. Analysis of overresponsive behaviors for each item and corroborating feedback from the examiners revealed that *refuse* overlapped with *negative* and that *aggressive* overlapped with *dislike,* suggesting that these be combined. Therefore, *refuse* was combined with *negative,* and *aggressive* was combined with *dislike.* Thus, four behavioral categories remained for subsequent analyses: *startle*, *elimination*, *dislike*, and *negative–stop*. Scoring was altered to be more sensitive by providing a range of options rather than absent–present, and all behavioral categories observed were recorded by the examiner, thus scores on items ranged from 1 to 4.

Item Validity. A seven-component factor analytic solution for both SensOR Scales provided the most interpretable pattern of loadings with no singleton factors. Although groups with and without sensory overresponsiveness were factored separately, both had the same factor solution. The scree test and variance calculation provided support for the solutions. Only a few of the items in the SensOR Assessment and the SensOR Inventory cross-loaded on two factors, which appeared consistent with the content of the items (see Tables 1 and 2).

We excluded items without a clear factor representation from the pilot version of the scale. A limitation of this study was that, because of the small sample size and the large numbers of items, eigenvalues are likely to be overestimated.

On the basis of these analyses, we developed the research edition of the SensOR Scales. The SensOR Assessment was reduced from 21 subtests to 16 and from 90 items to 53. The scoring system was simplified as described to four rather than six behavioral categories; however, the score range was increased for each item from 0–1 to 1–4, resulting in a larger range of scores and greater sensitivity. A summary of test tasks in the research edition of the SensOR Assessment appears in the Appendix. The SensOR Inventory was modified from 143 items to 76 items.

Table 1. Factor Loading of Sensory Over-Responsivity Assessment Pilot Version Items for the Sensory Overresponsive Group

Item	Visual–Rotation	Auditory	Movement	Proprioception	Tactile–ADLs	Light Touch–Textures	Gustatory–Olfactory
Sparkle wheel	0.56						
Strobe light	0.83						
Strobe light 2	0.91						
Strobe light 3	0.95						
Strobe light 4	0.92						
Strobe light 5	0.84						
Rotation to the right	0.67						
Rotation to the left	0.45						
Background noise, 40 s		0.68					
Background noise, 50 s		0.69					
Cymbals		0.36	0.43				
Stick and cymbal		0.41	0.53				
Police whistle		0.32	0.32				
Dog barking		0.45					
Blender		0.75					
Fire alarm		0.78					
Bees buzzing		0.73					
Clock ticking		0.68					
Vacuum cleaner		0.76					
Ball to right			0.85				
Ball to left			0.79				
Ball overhead, eyes open			0.72				
Ball overhead, eyes closed			0.67				
Somersault			0.29	0.33			
Stretch band, arms to side				0.87			
Stretch band, arms up				0.75			
Stretch band, legs				0.83			
Traction, right arm				0.31			
Traction, left arm				0.55			
Band-Aid on right wrist					0.75		
Band-Aid on right hand					0.91		
Band-Aid on left wrist					0.85		
Band-Aid on left hand					0.90		
Animal in goo						0.61	
Animal in goo						0.63	
Air puff to left cheek						0.61	
Feather to left face						0.59	
Puff to right face						0.66	
Feather to right face						0.50	
Fruit roll-up							0.60
Sour candy							0.45
Tapioca pudding						0.54	0.31
Brush teeth							0.33
Pop Rocks candy							0.73
Lemon							0.61
Wintergreen							0.63

Note. ADLs = activities of daily living.

Stage 2: Reliability and Validity of the SensOR Research Edition on Sample 1

Internal Consistency Reliability. Analyses of the SensOR Assessment revealed moderate to high internal consistency reliability for the domains (rs = .60–.89) and the total test (r = .92; see Table 3). The reliability estimates for the SensOR Inventory ranged from .65 to .88 for the domains; for the total test, it was .97 (see Table 4).

Interrater Reliability. We examined the consistency of the SensOR Assessment by computing Pearson product–moment correlations for 25 participants between two raters, one of whom administered the assessment and rated the participant's performance, the other of whom observed and independently rated performance. We obtained moderate to high interrater reliability for the total test (r = .75) and for each of the domains (rs = .63–.89). Table 3 depicts internal consistency and interrater reliability for the SensOR Assessment.

Discriminant Validity. We evaluated discriminant validity by comparing the typically developing group with the sensory overresponsivity group for both scales (see Tables 5 and 6). For both SensOR Scales, the total test and domain scores discriminated groups (overresponsive vs. typically developing) at a meaningful and statistically significant level (significance by domain ranged from $p < .05$ to $p < .001$). The distributions were nonnormal and positively skewed. Therefore, we used the Satterthwaite–Welch t test to accommodate the differences in variance resulting from different ranges of scores for the two groups. The effect sizes of differences denote medium to large effects for most domains. As expected, we noted greater variance, as evidenced by higher

Table 2. Factor Loading of Sensory Over-Responsivity Inventory Pilot Version Items for the Sensory Overresponsive Group

		Auditory			Tactile		Food	
Item	Visual–Olfactory	Specific	Settings	Proprioception–Movement	Daily Living	Texture	Texture	Other
Perfume	0.78							
Fresheners	0.77							
Bath products	0.68							
Clutter	0.61							
Fast TV	0.61							
Cleaners	0.59							
Lights	0.54							
Soaps	0.42							
Escalators	0.31							
Clock ticking		0.69						
Bell		0.68						
Clothes		0.67						
Siren		0.66						
Talking		0.66						
Utensils		0.64						
Alarm		0.55						
Dog		0.53						
Water		0.52						
Construction equipment		0.51	0.44					
Radio		0.50						
Fluorescent lights		0.48						
Concert			0.73					
Appliances, kitchen			0.72					
Parade			0.68					
Gymnasium			0.68					
Toilet, bathroom			0.67					
Restaurant			0.61					
Large gatherings			0.60					
Mall			0.49					
Chewy foods				0.83				
Stiff when moving				0.68				
Heights				0.66				
Climbing				0.63				
Moving surfaces				0.52				
Stairs				0.48				
Amusement park				0.46				
Swings, slides				0.45				
Jungle gym				0.41				
Cutting nails					0.39	0.38		
Haircut					0.36	0.31		
Pants					0.69			
Light touch					0.65			
Seams					0.62			
Fuzzy					0.58			
Kissing					0.56			
Carpet					0.56			
Socks					0.53			
Accessories, hat					0.51			
Shower					0.50			
Tags					0.50			
Getting dressed					0.48			
Wool					0.46			
Elastic					0.45			
Brushing teeth					0.44			
Hair washing					0.40			
Hair brushing					0.40			
Wash, wipe face					0.28			
Mud						0.85		
Dirt						0.82		
Messy mouth						0.81		
Glue						0.71		
Messy hands						0.64		
Crumbs on mouth						0.64		
Fingerpaint						0.61		
Food on hands						0.60		
Barefoot on dirt						0.56		
Play-doh						0.54		
Hair products					0.39	0.47		
Soft foods							0.72	
Lumpy foods							0.67	
Salty							0.64	
Soup with vegetables							0.59	
Slimy food							0.50	
New foods							0.49	0.68
Spicy								0.66
Smell of food								0.63
Eating bread crust								0.53

Table 3. Interrater and Internal Consistency Reliability for the Research Edition of the Sensory Over-Responsivity Assessment: Sample 1

Domain	Interrater Correlation (n = 25)	Coefficient α Reliability
Tactile	.83	.83
Auditory	.89	.89
Visual	.63	.94
Proprioceptive	.84	.84
Olfactory	.66	.70
Gustatory	.84	.60
Vestibular	.69	.76
Total	.75	.92

Table 4. Internal Consistency Reliability of the Research Edition of the Sensory Over-Responsivity Inventory: Sample 1

Domain	Coefficient α Reliability
Tactile	
Daily living	.88
Textures	.87
Auditory	
Specific	.85
Settings	.84
Visual–olfactory	.83
Movement–proprioceptive	.80
Food	
Texture	.66
Other	.65
Total	.97

standard deviations, in the sensory overresponsive group than in the typically developing group. We also noted variability in scores within each domain, likely because of the wide range in age of the participants.

When we analyzed discriminant validity separately for children ages 3 to 16 and for adults ages 17 to 55, both scales differentiated between the sensory overresponsive group and the typically developing group: for children, SensOR Assessment, $t[87] = -3.60, p < .001$, and SensOR Inventory, $t[87] = -4.77, p < .001$; for adults, SensOR Assessment, $t[34] = -6.33, p < .001$, and SensOR Inventory, $t[34] = -4.58, p < .001$.

Concurrent Validity. We assessed concurrent validity of the SensOR Scales research edition by correlating them with validity measures. The first analysis was for ages 3 to 16 (n = 89) and compared the SensOR Scales to the SSP, using the average raw score on the four overresponsive subtests (i.e., tactile, taste–smell, visual–auditory, and movement). The second analysis included ages 17 to 55 (n = 36) and compared the SensOR Scales to the ASP, using the raw scores for the sensory sensitivity and sensory-avoiding quadrants. In children, the correlation between the SensOR Assessment and the SSP overresponsive subtests was statistically significant ($r = .50, p < .01$). In adults, the association between the sensory overresponsive scores from the ASP and the SensOR Assessment was also statistically significant (sensory-sensitivity dimension, $r = .64, p < .01$; sensory-avoiding dimension, $r = .69, p < .01$). Correlations were even higher between the SensOR Inventory and the SSP ($r = .87, p < .001$) and the ASP (sensory-sensitivity dimension, $r = .79, p < .001$; sensory-avoiding dimension, $r = .73, p < .001$).

Stage 3: Cross-Validation of Reliability and Validity of the SensOR Research Edition on Sample 2

To validate the findings of the SensOR research edition's reliability and validity, we recruited a second unrelated sample, as detailed in the Participants section. The following provides a summary of the SensOR Scales' reliability and validity on the basis of data from Sample 2.

Table 5. Means, Standard Deviations, *t* Test, and *p* Values for Domain and Total Scores of the Typical and Sensory Overresponsive Groups on the Sensory Over-Responsivity Assessment Research Edition: Sample 1

	Typical (n = 60)		Sensory Overresponsive (n = 65)				
Domain	*M*	*SD*	*M*	*SD*	*t*	*p*	Effect Size
Tactile	0.18	0.23	0.51	0.41	–5.65	<.001	1.02
Auditory	0.16	0.28	0.42	0.42	–4.13	<.001	0.74
Visual	0.13	0.33	0.39	0.6	–3.13	.002	0.55
Proprioceptive	0.07	0.22	0.25	0.4	–3.01	.003	0.57
Olfactory	0.03	0.12	0.10	0.27	–2.03	.046	0.10
Gustatory	0.27	0.31	0.52	0.5	–3.34	.001	0.61
Vestibular	0.14	0.23	0.35	0.38	–3.87	<.001	0.68
Total	7.97	7.87	20.3	13.6	–6.24	<.001	1.14

Note. df = 123 for each *t* test.

Table 6. Means, Standard Deviations, *t* Test, and *p* Values for Domain Scores for the Typical and Sensory Overresponsive Groups on the Sensory Over-Responsivity Inventory Research Edition: Sample 1

	Typical (*n* = 60)		Sensory Overresponsive (*n* = 65)				
Domain	*M*	*SD*	*M*	*SD*	*t*	*p* <	Effect Size
Tactile	2.68	3.40	11.49	8.62	–7.6	.001	1.44
Auditory	1.10	1.67	6.34	5.83	–6.94	.001	1.36
Visual	0.35	0.71	1.35	1.20	–5.73	.001	1.04
Proprioceptive	0.03	0.18	0.57	0.87	–4.88	.001	1.00
Olfactory	0.25	0.84	1.52	1.98	–4.75	.001	0.87
Gustatory	1.07	1.18	3.09	2.62	–5.65	.001	1.05
Vestibular	0.62	1.18	2.71	2.98	–5.23	.001	0.99
Total	4.03	4.76	18.58	13.97	–7.92	.001	1.52

Note. df = 123 for each t test.

Internal Consistency Reliability. The analysis of the second sample replicated previous findings for the SensOR Assessment, demonstrating moderate to high internal consistency reliability for the seven domains (rs = .53–.90) and the total test score (r = .72; see Table 7). The reliability estimate for the SensOR Inventory ranged from .62 to .83 for the domains; for the total test, it was .94 (see Table 8).

Discriminant Validity. We assessed discriminant validity by comparing scores of the typically developing and sensory overresponsivity groups. The total test and domain scores for both SensOR Scales (see Tables 9 and 10) discriminated groups at a meaningful and statistically significant level (for domains, range = $p < .05$ to $p < .001$). The effect sizes of group differences are similar to those found in Sample 1, medium to large effects for most domains. Mean scores were higher for Sample 2 because the revised scoring system allowed for multiple behaviors to be observed and recorded for each item. However, as found in Sample 1, higher standard deviations were found in the sensory overresponsive group than in the typically developing group, and greater variability existed within each sensory domain, likely because of the wide range in age of the participants.

We evaluated age discrimination in a similar manner for children ages 3 to 17 and for adults ages 18 to 55. Again, the scales differentiated between the sensory overresponsive and typically developing groups in both children and adults: for children, SensOR Assessment, $t[64] = –4.39$, $p < .001$, and SensOR Inventory, $t[64] = –4.04$, $p < .001$; for adults, SensOR Assessment, $t[24] = –3.72$, $p < .002$, and SensOR Inventory, $t[24] = –3.27$, $p < .006$.

Concurrent Validity of the SensOR Research Edition. We also assessed concurrent validity for Sample 2. The performance of 3- to 16-year-old participants (n = 75) on the SensOR Scales was compared with results on the SSP, and the performance of 17- to 55-year-old participants (n = 17) was compared with results on the ASP. In children, the correlation between the SensOR Assessment and the SSP overresponsive subtests was statistically significant ($r = .47$, $p < .01$). In adults, the ASP scores were also significantly related (sensory-sensitivity dimension, $r = .74$, $p < .01$, and sensory-avoiding dimension, $r = .59$, $p < .01$). Comparisons of the SensOR Inventory and the Sensory Profile Scales were also

Table 7. Internal Consistency Reliability for the Sensory Over-Responsivity Assessment Research Edition: Sample 2

Domain	Coefficient α Reliability
Tactile	.90
Auditory	.53
Visual	.90
Proprioceptive	.67
Olfactory	.81
Gustatory	.78
Vestibular	.83
Total	.72

Table 8. Internal Consistency Reliability of the Sensory Over-Responsivity Inventory Research Edition: Sample 2

Domain	Coefficient α Reliability
Tactile	
Daily living	.81
Textures	.77
Auditory	
Specific	.78
Settings	.83
Visual	.74
Olfactory	.80
Movement–proprioceptive	.74
Food texture–issues	.62
Total	.94

Table 9. Means, Standard Deviations, *t* Test, and *p* Values for Domain and Total Scores of Typical and Sensory Overresponsive Groups on the Sensory Over-Responsivity Assessment Research Edition: Sample 2

	Typical (n = 44)		Sensory Overresponsive (n = 48)				
Domain	*M*	*SD*	*M*	*SD*	*t*	*p*	Effect Size
Tactile	1.66	1.93	5.13	6.06	–3.68	<.001	0.85
Auditory	1.18	1.99	4.06	3.48	–4.82	<.001	1.04
Visual	0.32	0.80	2.00	3.68	–2.97	.004	0.73
Proprioceptive	0.36	0.87	1.29	1.73	–3.22	.002	0.70
Olfactory	0.64	1.08	1.17	1.40	–2.02	.047	0.42
Gustatory	0.93	1.81	3.02	3.16	–3.85	<.001	0.83
Vestibular	0.41	0.95	2.48	3.29	–4.03	<.001	0.95
Total	6.05	5.24	18.6	14.41	–5.46	<.001	1.25

Note. df = 86 for tactile, auditory, visual, proprioceptive, and olfactory domains. *df* = 90 for gustatory and vestibular domains and total.

significant (children, $r = .67$, $p < .001$; adults, sensory-sensitivity dimension, $r = .74$, $p < .001$; sensory-avoiding dimension, $r = .64$, $p < .001$).

Post Hoc Analyses. Correlations among the sensory domains ranged from .15 to .77. Analysis of the association between the sensory sensitivity and sensory-avoiding dimensions on the ASP found a significant correlation between the dimensions for Sample 1 ($r = .77$, $p < .01$) and for Sample 2 ($r = .84$, $p < .001$).

Discussion

Summary of Findings: Reliability and Validity of the Scales

This study suggests that the SensOR Scales (research edition) are reliable on the basis of the results for Sample 1 and cross-validation using a second independent sample (Sample 2). The similar findings of moderate to high internal consistency in Samples 1 and 2 suggest that the items within the sensory domains of each scale are relatively homogeneous. In addition, moderately high interrater reliabilities from Sample 1 suggest that consistency can be obtained between examiners' interpretations of child behaviors when examiners are trained using a videotape and detailed study of a manual. Because interrater reliability was high for Sample 1, we did not repeat the study of interrater reliability for Sample 2.

This study provides preliminary evidence for the content and construct validity of the research edition of the SensOR Scales. For both scales, all of the sensory domain scores discriminated between the typically developing and sensory overresponsive groups in two studies using unrelated samples. All but one subtest (in Sample 1) had medium or large effect sizes, suggesting meaningful and significant differences.

Table 10. Means, Standard Deviations, *t* Test, and *p* Values for Domain Scores for Typical and Sensory Overresponsive Groups on the Sensory Over-Responsivity Inventory Research Edition: Sample 2

	Typical (n = 44)		Sensory Overresponsive (n = 48)				
Domain	*M*	*SD*	*M*	*SD*	*t*	*p* <	Effect Size
Tactile							
Self-care	3.16	2.31	6.02	4.40	–4.34	.001	0.91
Materials	0.63	0.99	2.34	2.71	–4.57	.001	1.02
Auditory							
Sounds	1.41	1.50	3.12	2.97	–3.88	.001	0.82
Places	0.29	0.63	2.02	2.35	–5.58	.001	1.32
Visual	0.30	0.64	1.32	1.57	–4.59	.001	1.02
Olfactory	0.64	1.04	1.41	1.76	–2.84	.001	0.58
Gustatory	1.30	1.32	2.51	1.90	–3.84	.001	0.78
Vestibular–proprioception	0.40	0.61	1.32	1.98	–3.45	.001	0.80
Total	8.08	5.41	19.71	14.85	–4.81	.001	1.27

Note. df = 86 for tactile self-care, materials, auditory sounds, places, visual, olfactory, and vestibular–proprioceptive domains. *df* = 90 for gustatory domain and total.

Procedures should be replicated with evaluators who are unaware of participants' group.

Construct validity is further suggested by the significant correlations between the subtests of the SensOR Assessment and Inventory and the results of the factor analyses, which were consistent with the theoretical construction of the scales. The wide range of correlations among the sensory domains suggests that more than one type of sensory overresponsivity may exist. Further study is needed to determine whether sensory overresponsivity is a single construct or a multidimensional subtype.

Correlations between the SensOR Assessment and Inventory were statistically significant; however, all were <.40, suggesting that the scales measure similar but not the same constructs. This finding can be interpreted as evidence that both a performance measure and a parent–self-report measure are needed to evaluate people with sensory overresponsivity because different information is provided by a respondent than by a person directly observing performance. Obtaining information from caregivers or self facilitates an understanding of how an individual's sensory behaviors are perceived in multiple environments; however, responses can be influenced by the parent's expectations, interpretations, and reactions to the child's behavior. This is the first study in the occupational therapy literature to evaluate a performance measure using direct observation by trained examiners to evaluate sensory overresponsivity. A measure of direct observation, when used in combination with a caregiver–self-report measure provides a more complete assessment of the individual (Achenbach & Rescorla, 2004).

Convergent validity was revealed in two separate samples with significant relations between the SensOR Scales and the SSP's or ASP's sensory-sensitivity and sensory-avoiding dimensions. The association between sensory sensitivity and sensory avoiding on the ASP supports Brown et al.'s (2001) factor analysis demonstrating that sensory-sensitivity and sensory-avoiding items tend to load together; however, it calls into question whether sensory sensitivity and avoiding are actually separate constructs. Further study of the relation between Dunn's (1997) hypothesized dimensions of sensory sensitivity and sensory avoiding is warranted.

Limitations

The research edition of the SensOR Scales requires further study before it is ready for widespread use. Studies are under way to assess additional psychometric characteristics. A test–retest study to determine the stability of the scales over time and an evaluation of performance on the SensOR Assessment by testers unaware of group membership are also under way. In addition, to better understand the significance of sensory overresponsivity, ongoing research is necessary to evaluate its association with functional behavior.

Importance of This Research to Evidence-Based Practice

One central task of evidence-based practice is the selection of assessment procedures (Tickle-Degnen, 1999). The goal is to use tools that are reliable and provide meaningful results. In light of the current health care climate in which accountability is prioritized and resources are limited, therapists must optimize their efficiency and effectiveness by using the best existing evidence to make clinical decisions (Christiansen & Lou, 2001; Holm, 2000).

This study provides preliminary evidence that the SensOR Scales are reliable and valid evaluations of sensory overresponsivity. With further study, these scales may contribute to evidence-based decisions related to whether a particular individual exhibits clinical signs of sensory overresponsivity.

Using multiple sources of assessment data is critical to the process of evidence-based practice (Foster & Cone, 1980; Haynes & O'Brien, 2000). Recent research has suggested that behavioral report measures (Achenbach & Rescorla, 2004; Clayton, Fleming, & Copley, 2003), which are cross-validated by performance assessment findings (Baranek & Berkson, 1994), may be the most predictive and have the greatest utility for developing intervention plans. Thus, the potential for the SensOR Scales to provide two sources of data, direct observation and caregiver–self-report, is a strength of these new measures.

Another central task of evidenced-based practice is the systematic evaluation of research findings related to intervention outcomes. Outcome studies are a priority of the occupational therapy profession (Dubouloz, Egan, Vallerand, & von Zweck, 1999; Dysart & Tomlin, 2002; Holm, 2000; Tickle-Degnen, 1998, 1999). As Tickle-Degnen (2000) recommended, intervention studies must use assessment tools that have both discriminant validity and interrater reliability. Outcome research in occupational therapy is challenged by the need to develop measures that are sensitive to the changes that occur in therapy (Bundy et al., 2002; Polatajko, Kaplan, & Wilson, 1992). Recent findings have suggested that some examiner-administered assessments may be useful tools for measuring change following some interventions (Azouvi et al., 2003; Baranek & Berkson, 1994; Clayton et al., 2003). The SensOR Scales appear to have the potential to be used as outcome measures. Establishing test–retest stability and further study of its sensitivity over time will define its utility for this purpose.

Finally, outcome research with people who have sensory modulation disorder is challenged by the lack of adequate tools to classify people into subtypes with homogeneous behaviors.

The SensOR Scales address this problem by providing specific information on sensory overresponsivity only. The diagnostic usefulness of many scales is limited because sensory overresponsivity is assessed in only one sensory system. The SensOR Scales address this by evaluating all sensory domains.

The new taxonomy of sensory processing disorder includes three clinical groupings of sensory modulation disorder—(1) sensory overresponsivity, (2) sensory underresponsivity, and (3) sensory seeking—as recently adopted by the *Diagnostic Manual for Infancy and Early Childhood* (ICDL, 2005) and by the *Diagnostic Classification: 0-3–Revised* (Zero to Three, 2005). Psychophysiologic evidence also indicates that over- and underresponsive groups exist in people with sensory modulation disorder (McIntosh, Miller, Shyu, & Hagerman, 1999). Scales need to be developed that are theoretically linked to this conceptualization. Whether sensory modulation disorder is a homogeneous disorder or includes multiple subtypes must be evaluated. An evaluation tool that accomplishes this purpose will facilitate use of targeted assessment for the selection of the most appropriate intervention and increase power to evaluate questions about effectiveness. Continued refinement of the SensOR Scales is one step toward achieving this goal.

Conclusion

The SensOR Scales offer a unique contribution to evidenced-based practice by specifically measuring sensory overresponsivity across all seven sensory domains, combining a directly administered performance measure and a subjective, caregiver-report (for children) or self-report (for adults) measure. The scales provide a method to assess people in a standard manner across a diverse age range (3 through adults) and across severity (subtle to overt behaviors). The preliminary psychometric integrity of the scales is promising and suggests future research to increase the effectiveness of further use of these scales in clinical decision making. ▲

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Appendix.

Description of Activities in the Sensory Over-Responsivity Assessment Research Edition

1. Response to removal of a Band-Aid from a pretend cut on the hands or wrists
2. Response to finding an animal hidden in special goo
3. Response to an air puff or feather on face while finding hidden pictures on a paper
4. Response to background noise audiotape while finding more hidden pictures on the page
5. Response to accompanying audiotape with different musical instruments
6. Response to hearing specific sounds and pointing to a picture that best matches the sound
7. Response to watching a sparkle wheel while making it spin for 20 sec
8. Response to visual stimuli while playing a lightning storm game saving animals that got left out in the storm
9. Response to stretching a large band into horizontal and vertical lines when pulled between the arms or legs
10. Response to being a "stretchy doll" and feeling traction to the shoulder of either arm
11. Response to specific smells and finding the picture that best matches the smell
12. Response to a snack time, tasting a selection of different-textured snack foods
13. Response to teeth-brushing activity after the snack time; using a foam brush to clean all parts of the mouth/teeth
14. Response to playing several games with a beach ball while sitting on a therapy ball: reaching in different planes of space with both hands to get the ball with the eyes either open or closed
15. Response to a pretend helicopter ride on a rotating chair, first going to the right and then to the left
16. Response to a circus game: (1) jumping off of a chair with eyes open and then with eyes closed and (2) trying to do a backwards somersault on a mat