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

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Key Words: Sensory Disorders, Sensory Modulation, Diagnosis-Related Groups, Assessment, Pediatrics, Adults

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Abstract

This article describes three 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 an Assessment, an examiner administered performance evaluation, and an Inventory, a caregiver/self-rating scale. Both scales measure sensory over-responsivity in seven sensory domains. Data were collected from two samples of typically developing individuals (n = 60; n = 44) and individuals with sensory over-responsivity (n = 65; n = 48), ages 3 to 55. Items on the pilot version were reviewed for their internal consistency reliability, discriminant validity, and construct validity in developing the research edition. Data were collected from both samples on the research edition revealing high internal consistency reliability for domains and the total test and significant discrimination between the over-responsive and the typically responsive groups ($p < .05$). The preliminary psychometric integrity of the scales, along with our continued research efforts, is an important contribution to evidence-based practice.

The Sensory Over-Responsivity Scales: Pilot Version and Research Edition

Sensory Modulation Disorder has been discussed in the Occupational Therapy (OT) literature for over 40 years (Ayres, 1964). However, empirical validation for the diagnostic validity of the condition is sparse. In part, this is due to the lack of an objective performance measure to identify the disorder in children and adults. In general, identifying persons with sensory modulation disorder and referring them for OT is based on clinical observations, self report or caregiver reports, and developmental/sensory history (Dunn, 1999; Johnson-Ecker & Parham, 2000). Recent advances in physiologic methods suggest that these methods have promise for the accurate identification of sensory modulation disorder (Mangeot, Miller, McIntosh, McGrath-Clarke, Simon, Hagerman, & Goldson, 2001; McIntosh, Miller, Shyu & Hagerman, 1999b; Miller, McIntosh, McGrath, Shyu, Lampe, Taylor, Tassone, Neitzel, Stackhouse, & Hagerman, 1999; Schaaf, Miller, Sewell, & O'Keefe, 2003); however, the existing performance evaluation methods only screen for Sensory Modulation Disorder. Thus, a need exists to develop a diagnostic evaluation of Sensory Modulation Disorder for practicing clinicians.

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 socio-political climate related to shrinking health care resources mandates that assessment procedures be chosen that have demonstrated reliability and validity (Christiansen & Lou, 2001; Holm, 2000). OT, 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 over-responsivity in the tactile system. She later identified gravitational insecurity and abnormal autonomic responses to movement as additional indicators of sensory over-

responsivity affecting the vestibular system (Ayres, 1972a; 1972b; 1979). These constructs were later expanded to include a common triad of over-responsivity 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 over-responsivity (defensiveness) and its relation to other types of sensory over-responsivity is limited.

Other researchers have elaborated on the construct of over-responsivity in young children (Bar-Shalita, Goldstand, Hahn-Markowitz & Parush, 2005; Provost & Oetter, 1993), specifically within the tactile domain (C.B. Royeen, 1985, 1986; C.B Royeen & Fortune, 1990) and among different clinical populations (Baranek & Berkson, 1994; Kinnealey, 1973; Pfeiffer, Kinnealey, Reed, & Herzberg, 2005). Sensory over-responsivity is conceptualized in Dunn's model (1997) by two behavioral response continua, sensory sensitivity and sensory avoiding. Sensory sensitive individuals are described as fearful and cautious or negative and defiant, while sensory avoiding individuals 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; C. R. 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: Sensory Over-Responsivity (defined below), Sensory Under-Responsivity and Sensory Seeking. This terminology was recently incorporated into the Interdisciplinary Council for Developmental and Learning Disorders (ICDL): Diagnostic Manual (ICDL, 2005) and the Diagnostic Classification (DC): Zero to Three (Zero To Three, 2005). Sensory Over-Responsivity is proposed 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 Over-Responsivity is a logical starting point for empirical validation and advocacy for inclusion in additional diagnostic taxonomies such as the Diagnostic and Statistical Manual because the behaviors are readily observable.

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

Recent research suggests 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 Processing Disorder (Ahn, Miller, Milberger, & McIntosh, 2004). The raw data were obtained from the authors and reanalyzed to evaluate the incidence of Sensory Over-Responsivity by excluding items that measured other aspects of sensory processing. Prevalence rates of Sensory Over-Responsivity varied from 2.8% to 6.5% across tactile, movement, visual/auditory, and taste/smell domains. Similar prevalence rates for Sensory Over-Responsivity were obtained in a study of a community sample of twins (Goldsmith, Van Hulle, Arneson, Schreiber & Gernsbacher, 2003).

The most commonly used standardized caregiver, or self-questionnaires, are the Sensory Profile Scales for various ages (C. Brown, Tollefson, Dunn, Cromwell & Filion, 2001; Dunn, 1994, 1999; Dunn & Brown, 1997). However, interpretation of the sensory impairments evaluated by the Sensory Profile (Dunn, 1999) is complicated by the inclusion of emotional and fine motor items in addition to sensory processing items. Interpretation 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 Over-Responsivity 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 over-responsivity in only one sensory domain; 4) designed for a limited age group; and 5) lack of normative information or reliability and validity studies.

Literature suggests that direct observation by a trained professional can contribute to a more reliable and predictive assessment when used in combination with caregiver-report or self-report scales (Achenbach & Rescorla, 2004; Baranek, 1998; Baranek & Berkson, 1994; Baranek, Foster, & Berkson, 1997). Therefore, the use of a performance measure where 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 Over-Responsivity using direct observation exist in the OT literature, though these studies did not result in assessments that therapists could utilize. 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 (TDDT) (Baranek, 1998), was designed for children with developmental disabilities and measures over-responsivity in only one sensory system (Baranek, 1998). Neither the Kinnealey nor Baranak study reports standardized procedures or data from a normative sample. Thus, a new evaluation system that includes both caregiver report and a performance measure of multiple domains of sensory functioning with adequate reliability and validity is needed to objectively evaluate sensory over-responsivity.

Method

A measure of Sensory Over-Responsivity was constructed and psychometric characteristics were evaluated in this study. The project included three stages. Stage 1, the Instrument Development stage, produced a pilot version of both the performance assessment and rating scale. Following item analysis, this stage resulted in development of a new edition of both scales called the research edition of the Sensory Over-Responsivity (SensOR) Assessment and Sensory Over-Responsivity (SensOR) Inventory. Stage 2 evaluated the reliability and validity of the research edition by analyzing the internal consistency and the construct validity of the scales with Sample 1. Stage 3 addressed the need to cross-validate findings through examination of reliability and validity of the research edition on a second sample.

Participants

Two separate samples were recruited. Sample 1 participated in Stage 1 and Stage 2, the development of the pilot versions and 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.

Participants for Stage 1 and Stage 2

Subjects in Sample 1 were 125 individuals between the ages of 3 and 55. Sixty were typically developing individuals and 65 were referred with symptoms of sensory over-responsivity.

Identification of the Sensory Over-Responsive sample: The 65 individuals with sensory over-responsivity 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 over-responsive participants based on global assessments of functioning and were blind to the items on the SensOR Assessment and Inventory. The only criterion for inclusion was the presence of over-responsivity in one or more sensory domains, which the therapist felt interfered significantly with daily life activity. The Short Sensory Profile (SSP) or the Adult Sensory Profile (ASP) was administered after the therapist referred the child to the study to confirm the participant's classification in the sensory over-responsivity group. Participants who endorsed a majority of sensory over-responsive items in one or more sensory domains on the Dunn scales were retained in the sample. No subjects were excluded based on their score on the SSP or ASP.

Identification of the Typically Developing sample: A telephone interview was conducted to recruit the 60 individuals without sensory over-responsivity. Each site recruited a convenience sample of typically developing individuals and used the questions on the telephone interview to confirm the lack of sensory over-reponsivity. Inclusion criteria included: no history of unusual sensory sensitivity; no birth risk factors (e.g., prematurity, NICU 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., children 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 over-responsive groups on age, gender, or ethnicity.

Participants for Stage 3

A second sample, with no overlapping participants from the previous studies, was recruited for Stage 3. Sample 2 had 44 typically developing individuals and 48 with symptoms of sensory over-

responsivity. Procedures for inclusion and inclusion criteria and group matching for typically developing subjects was the same as described for Sample 1 above. None of the sensory over-responsive participants in the second sample had comorbid diagnoses. This sample also had no significant group differences on age, gender, or ethnicity.

Procedures

The Sensory Over-Responsivity (SensOR) Scales include two separate scales: 1) the Sensory Over-Responsivity (SensOR) Assessment, an examiner administered performance scale, and 2) the Sensory Over-Responsivity (SensOR) Inventory, a caregiver/self rating scale. Stage 1, the instrument development phase, began with a thorough review of related theoretical literature. Over 60 references were used to support item selection. Included were both textbooks (Bundy, Lane & 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; C. E. Brown & Dunn, 2002; DeGangi & Balzer-Martin, 2000; DeGangi & Poisson, 2000; Dunn, 1999; Dunn & Daniels, 2000; Parham & Johnson-Ecker, 2002; Provost & Oetter, 1993; C.B. Royeen, 1987; C.B Royeen & Fortune, 1990).

Next, preliminary versions of the SensOR Assessment and the SensOR Inventory were developed, organized by sensory domain. Each domain of the Assessment includes subtests (activities similar to daily occurrences) comprised of clusters of items. The SensOR Inventory has a parallel format to the SensOR Assessment, with items clustered within sensory domains to be rated by a respondent (self or parent). For the SensOR Assessment, a rating system was developed 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 OT clinicians. Using an informal Delphi structure, researchers and clinicians rated each item on the SensOR Assessment and SensOR Inventory. Based on expert feedback, the scales were revised. The best set of non-overlapping items for each scale that represented functional aspects of sensory over-responsivity occurring during daily life activities and routines were retained in each scale.

The SensOR Assessment and SensOR Inventory were administered to five 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 consisting of 90 items divided into 21 subtests. For example, one auditory subtest was an audiotape of sounds (e.g., police sirens and vacuum cleaners that typically elicit over-responsivity).

The scoring of the pilot version of the SensOR Assessment was a count of the over-responsive 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 over-responsive behaviors for each subtest; sensory domain scores were also compiled.

The pilot version of the SensOR Inventory consisted of 143 items in 16 stem questions that describe 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 versus not applicable, with each item receiving a total score of 0 or 1. The child's total score was the total number of over-responsive behaviors endorsed by parent or self (over age 16) and subtest scores were complied for each sensory domain.

Validation instrumentation

The Short Sensory Profile (SSP) is a short version of the Sensory Profile (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, 1999a).

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

Data collection

Information about standard procedures was provided to six collaborating sites, professionals who are members of the Sensory Processing Disorder Scientific Workgroup (www.kidfoundation.org/research), who recruited individuals with and without sensory over-responsivity. A written informed consent was obtained from all parents (and assent from children over 7 years) prior to participation in the study.

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

Data for all stages were collected over a five-month period by the primary examiner at each collaborating site. Test administration was conducted in a quiet, non-distracting room, lasting approximately one hour per subject. Adult participants or parents of child participants completed: 1) a demographic form, 2) the SSP (McIntosh et al., 1999a) for ages 3-16 or the ASP for ages 17 and older (C. E. 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 typically developing and sensory over-responsive groups.

Construct validity was assessed using 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 over-responsiveness were factored separately.

Pragmatic validity was provided throughout the study. The utility/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 the ease of administration.

At the conclusion of these analyses a new version of the SensOR Assessment and the SensOR Inventory was constructed called the research edition.

Stage 2 and Stage 3: Reliability and validity of the SensOR research edition

The internal consistency reliability was examined for each sensory domain. Discriminant validity determined the degree to which each sensory domain differentiated between participants with and without sensory over-responsivity. All analyses were conducted on Sample 1 and Sample 2.

Results

Stage 1: Instrument Development

Item pool reduction

Based on the results of the item analyses, the item pool of the pilot version of the SensOR Scales was reduced. Items were eliminated if they demonstrated either of the following: 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), and 2) non-significant discrimination between the groups with and without sensory over-responsivity ($t < 2.0$, $p > .05$).

Item scoring category simplification for the SensOR Assessment

The SensOR Assessment scores are a count of the number of over-responsive behaviors observed. Analysis of over-responsive 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 the SensOR Scales provided the most interpretable pattern of loadings with no singleton factors. Although groups with and without sensory over-responsiveness 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 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).

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

Insert Tables 1-2 about here

Based on these analyses, the research edition of the SensOR Scales was developed. The SensOR Assessment was reduced from 21 subtests to 16 and from 90 items to 53. The scoring system was simplified as described above 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.

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 (r = .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, and .97 for the total test (see Table 4).

Inter-rater reliability

Consistency of the SensOR Assessment was examined by computing Pearson product moment correlations between two raters for 25 participants, one of whom administered the assessment and rated the participant's performance while the other observed and independently rated performance. Moderate to high inter-rater reliability was obtained for the total test (r = .75) and for each of the domains (r = .63-.89). Table 3 depicts internal consistency and inter-rater reliability for the SensOR Assessment.

Insert Tables 3 and 4 about here

Discriminant validity

Discriminant validity was evaluated by comparing the typically developing group to the group with sensory over-responsivity for both scales (see Tables 5 and 6). For both SensOR Scales, the total test and domain scores discriminated groups (over-responsive vs. typically developing) at a meaningful and statistically significant level (significance by domain ranged from $p < .05$ to $< .001$). The distributions were nonnormal and positively skewed. Therefore, the Satterthwaite/Welch t-test to accommodate the differences in variance due to different ranges of scores for the two groups was utilized. The effect sizes of differences denote medium to large effects for most domains. As expected, greater variance, as evidenced by higher standard deviations, is noted in the sensory over-responsive group as compared to the typically developing group. Variability is also noted in scores within each domain likely due to the wide range in age of the participants.

Insert Tables 5 and 6 about here

When discriminant validity was analyzed separately for children ages 3-16 and for adults ages 17-55 both scales differentiated between the sensory over-responsive group and typically developing groups (SensOR Assessment children: $t = -3.60$, $p < .001$; SensOR Inventory children: $t = -4.77$, $p < .001$; SensOR Assessment adults: $t = -6.33$, $p < .001$; SensOR Inventory adults: $t = -4.58$, $p < .001$).

Concurrent validity

Concurrent validity of the SensOR research edition was assessed by correlating the SensOR Scales with validity measures. The first analysis was for ages 3-16 (n = 89) and compared the SensOR Scales to the Short Sensory Profile (SSP), using the average raw score on the four over-responsive subtests (i.e., tactile, taste/smell, visual/auditory, and movement). The second analysis included ages 17-55 (n = 36) and compared the SensOR Scales to the Adult Sensory Profile (ASP), using the raw scores for the sensory sensitivity and sensory avoiding quadrants. In children, the correlation between the SensOR Assessment and the SSP over-responsive subtests was statistically significant ($r = .50$, $p < .01$). In adults, the association between the sensory over-responsive scores from the Adult Sensory Profile 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 Short Sensory Profile ($r = .87$, $p < .001$) and the ASP (sensory sensitivity $r = .79$, $p < .001$; sensory avoiding ($r = .73$, $p < .001$).

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

To validate the findings of reliability and validity of the SensOR research edition a second unrelated sample was recruited as detailed in the participant section. The following provides a summary of reliability and validity of the SensOR Scales based on data from Sample 2.

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 (r = .53 - .90) and the total test score (r = .72) (see Table 7). The reliability estimates for the SensOR Inventory ranged from .62 to .83 for the domains, and .94 for the total test (see Table 8).

Insert Tables 7 and 8 about here

Discriminant validity

Discriminant validity was assessed by comparing scores of the typically developing and sensory over-responsivity groups. Both SensOR Scales (see Tables 9 and 10) total test and domain scores discriminated groups at a meaningful and statistically significant level (range $p < .05$ to $< .001$ for domains). 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, there were higher standard deviations in the sensory over-responsive group as compared to the typically developing group and overall greater variability within each sensory domain likely due to the wide range in age of the participants.

Insert Tables 9 and 10 about here

Age discrimination was evaluated in a similar manner for children ages 3-17 and for adults ages 18-55. Again, the scales differentiated between sensory over-responsive and typically developing groups in both children and adults (SensOR Assessment children: t = -4.39, $p < .001$, SensOR Inventory children: t = -4.04, $p < .001$ and SensOR Assessment adults: t = -3.72, $p < .002$; and SensOR Inventory adults: t = -3.27, $p < .006$).

Concurrent validity of the SensOR research edition

Concurrent validity was also assessed for Sample 2. Performance of individuals ages 3-16 (n = 75) on the SensOR Scales was compared to results on the SSP and 2) for individuals ages 17-55 (n = 17) the performance was compared to results on the ASP. In children, the correlation between the SensOR Assessment and the SSP over-responsive subtests was statistically significant ($r = .47$, $p < .01$). In adults, the ASP scores were also significantly related: sensory sensitivity ($r = .74$, $p < .01$) and sensory avoiding ($r = .59$, $p < .01$). Comparisons of the SensOR Inventory and the Sensory Profiles were also significant (children: $r = .67$, $p < .001$; adults: sensory sensitivity $r = .74$, $p < .001$; sensory avoiding $r = .64$, $p < .001$).

Post-hoc analyses:

Correlations amongst the sensory domains ranged from .15 to .77. Analysis of the association between sensory sensitivity and sensory avoiding on the ASP found a significant correlation between the dimensions for Sample 1 ($r = .77$, $p < .01$) as well as 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 based on 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 homogenous. In addition, moderately high inter-rater reliabilities from Sample 1, suggest that consistency can be obtained between examiners' interpretation of child behaviors when examiners are trained using videotape and detailed study of a manual. As inter-rater reliability was high for Sample 1, the study of inter-rater reliability was not repeated 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 typically developing and sensory over-responsive groups in two studies using unrelated samples. All but one subtest (in Sample 1) had medium or large effects sizes suggesting meaningful as well as significant differences. Procedures should be replicated with evaluators blinded to participants' group.

Construct validity is further suggested by the significant correlations between the subtests of the Assessment and the Inventory as well as the results of the factor analyses, which were consistent with the theoretical construction of the scales. The wide range of correlations amongst the sensory domains suggests that more than one type of sensory over-responsivity may exist. Further study is needed to determine if Sensory Over-Responsivity is a single construct or a multidimensional subtype.

Correlations between the 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 individuals with Sensory Over-Responsivity, since different information is provided by a respondent versus direct observation of performance. Obtaining information from caregivers/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 OT literature to evaluate a performance measure using direct observation by trained examiners to evaluate sensory over-responsivity. 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 or the ASP, 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 editions of the SensOR Scales require further study before they are ready for widespread use. Studies are underway 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 Assessment by testers 'blind' to group membership are also underway. In addition, to better understand the significance of Sensory Over-Responsivity, ongoing research is necessary to evaluate the association between Sensory Over-Responsivity and functional behavior.

Importance of this Research to Evidence-based Practice

One of the central tasks of evidence-based practice is the selection of assessment procedures (Tickle-Degnen, 1999). The goal is using tools that are reliable and provide meaningful results. In light of the current health care climate where accountability is prioritized and resources are limited, therapists must optimize their efficiency and effectiveness through the use of 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 Over-Responsivity. With further study, these scales may be able to contribute to evidence-based decisions related to whether a particular individual exhibits clinical signs of sensory over-responsivity.

Utilizing multiple sources of assessment data is critical to the process of evidence-based practice (Foster & Cone, 1980; Haynes & O'Brien, 2000). Recent research suggests 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 providing two sources of data, direct observation and caregiver/self report in the SensOR Scales, 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) recommends, intervention studies must use assessment tools that have both discriminant validity and inter-rater 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 suggest that some examiner administered assessments may be useful tools for measuring change following some interventions (Azouvi, Olivier, de Montety, Samuel, Louis-Dreyfus & Tesio, 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 the sensitivity over time will define its utility for this purpose.

Finally, outcome research with individuals who have Sensory Modulation Disorder is challenged by the lack of adequate tools to classify individuals into subtypes with homogenous behaviors. The SensOR Scales address this problem by providing specific information on Sensory Over-Responsivity only. The diagnostic usefulness of many scales is limited because Sensory Over-Responsivity is only assessed in 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: a) Sensory Over-Responsivity, b) Sensory Under-Responsivity, and c) Sensory Seeking as recently adopted by the ICDL (ICDL, 2005) as well as by the DC: Zero to Three–Revised (Zero To Three, 2005). Psychophysiologic evidence also indicates that an over and under-responsive group exists in individuals with Sensory Modulation Disorder (McIntosh et al., 1999b). 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 Sensory Over-Responsivity Scales offer a unique contribution to evidenced-based practice by specifically measuring sensory over-responsivity across all seven sensory domains, combining a directly administered performance measure and a subjective, caregiver (for children) or self- report (for adults) measure. The scales provide a method to assess individuals 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.

Acknowledgements

The authors thank the children and adults participating in this study and the testers located at The Children's Hospital of Denver, Occupational Therapy Associates, Boston; Colorado State University, Fort Collins; University of Colorado at Colorado Springs; University of Wisconsin at Madison; and Casa Colina Children's Services, Pomona. Primary funding for this work was provided by the Wallace Research Foundation. Additional support has been provided by an NIH grant to the second author (R21 HD41614-01) and a grant from Cure Autism Now. This research was also supported in part by Grant #M01 RR00069, General Clinical Research Centers Program, The Children's Hospital Research Institute Scholar Award, and the Coleman Institute for Cognitive Disabilities research fellowship. Support was also received from an NIH grant to the first author (T32MH15442). The administrative support of Dr. Dennis Matthews, Director of Rehabilitation is also gratefully acknowledged.

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Table 1

Factor loading of SensOR Assessment pilot version items for the sensory over-responsive group

Items	Visual/ Rotation	Auditory	Movement	Proprioception	Tactile -ADL	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 sec.		0.68					
Background noise 50 sec.		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 bussing		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 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

Table 2

Factor loading of SensOR Inventory pilot version items for the sensory over-responsive group

Items	Visual/ Olfactory	Auditory: Specific	Auditory: Settings	Proprioception/ Movement	Tactile: Daily Living	Tactile: Textures	Food: Texture	Food: 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		056	
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
Finger-paint			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

Inter-rater and internal consistency reliability for the research edition of the SensOR Assessment: Sample 1

Domain	Inter-rater Correlation (n = 25)	Coefficient Alpha Reliability
Tactile	0.83	0.83
Auditory	0.89	0.89
Visual	0.63	0.94
Proprioceptive	0.84	0.84
Olfactory	0.66	0.7
Gustatory	0.84	0.6
Vestibular	0.69	0.76
TOTAL	0.75	0.92

Table 4

Internal consistency reliability of the research edition of the SensOR Inventory: Sample 1

Domain	Coefficient Alpha Reliability
Tactile:	
Daily Living	0.88
Textures	0.87
Auditory:	
Specific	0.85
Settings	0.84
Visual / Olfactory	0.83
Movement/Proprioceptive	0.8
Food:	
Texture	0.66
Other	0.65
TOTAL	.97

Table 5

Means, standard deviations, t-tes,t and p values for domain and total scores of typical and sensory over-responsive groups on the SensOR Assessment research edition: Sample 1

	Sensory						
	Typical		Over-Responsive				
	n = 60		n = 65				
Domain	M	SD	M	SD	t-test	*p* value	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	.74
Visual	0.13	0.33	0.39	0.6	-3.13	0.002	.55
Proprioceptive	0.07	0.22	0.25	0.4	-3.01	0.003	.57
Olfactory	0.03	0.12	0.1	0.27	-2.03	0.046	.10
Gustatory	0.27	0.31	0.52	0.5	-3.34	0.001	.61
Vestibular	0.14	0.23	0.35	0.38	-3.87	< .001	.68
TOTAL	7.97	7.87	20.3	13.6	-6.24	< .001	1.14

Table 6

Means, standard deviations, t-test, and p values for domain scores for typical and sensory over-responsive groups on the SensOR Inventory research edition: Sample 1

	Sensory						
	Typical		Over-Responsive				
	n = 60		n = 65				
Domain	M	SD	M	SD	t-test	*p* value	effect size
Tactile	2.68	3.4	11.49	8.62	-7.6	< .001	1.44
Auditory	1.1	1.67	6.34	5.83	-6.94	< .001	1.36
Visual	0.35	0.71	1.35	1.2	-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	.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	.99
TOTAL	4.03	4.76	18.58	13.97	-7.92	< .001	1.52

Table 7

Internal consistency reliability for the SensOR Assessment research edition: Sample 2

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

Table 8

Internal consistency reliability of the SensOR Inventory research edition: Sample 2

Domain	Coefficient Alpha 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 over-responsive groups on the SensOR Assessment research edition: Sample 2

	Sensory						
	Typical		Over-Responsive				
	n = 44		n = 48				
Domain	M	SD	M	SD	t-test	*p* value	effect size
Tactile	1.66	1.93	5.13	6.06	-3.68	< .001	.85
Auditory	1.18	1.99	4.06	3.48	-4.82	< .001	1.04
Visual	.32	.80	2.0	3.68	-2.97	.004	.73
Proprioceptive	.36	.87	1.29	1.73	-3.22	.002	.70
Olfactory	.64	1.08	1.17	1.40	-2.02	.047	.42
Gustatory	.93	1.81	3.02	3.16	-3.85	< .001	.83
Vestibular	.41	.95	2.48	3.29	-4.03	< .001	.95
TOTAL	6.05	5.24	18.6	14.41	-5.46	< .001	1.25

Table 10

Means, standard deviations, t-test, and p values for domain scores for typical and sensory over-responsive groups on the SensOR Inventory research edition: Sample 2

	Sensory						
	Typical		Over-Responsive				
	n = 63		n = 41				
Domain	M	SD	M	SD	t-test	*p* value	effect size
Tactile: self-care	3.16	2.31	6.02	4.40	-4.34	< .001	.91
Tactile: materials	.63	.99	2.34	2.71	-4.57	< .001	1.02
Auditory: sounds	1.41	1.50	3.12	2.97	-3.88	< .001	.82
Auditory: places	.29	.63	2.02	2.35	-5.58	< .001	1.32
Visual	.30	.64	1.,32	1.57	-4.59	< .001	1.02
Olfactory	.64	1.04	1.41	1.76	-2.84	< .001	.58
Gustatory	1.30	1.32	2.51	1.90	-3.84	< .001	.78
Vestibular/ Proprioception	.40	.61	1.32	1.98	-3.45	< .001	.80
TOTAL	8.08	5.41	19.71	14.85	-4.81	< .001	1.27

Appendix

Description of Activities in the SensOR 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 seconds.
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 either the eyes 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.